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Soil Erosion and Conservation in the United States

An Overview

Richard Magleby
Carmen Sandretto
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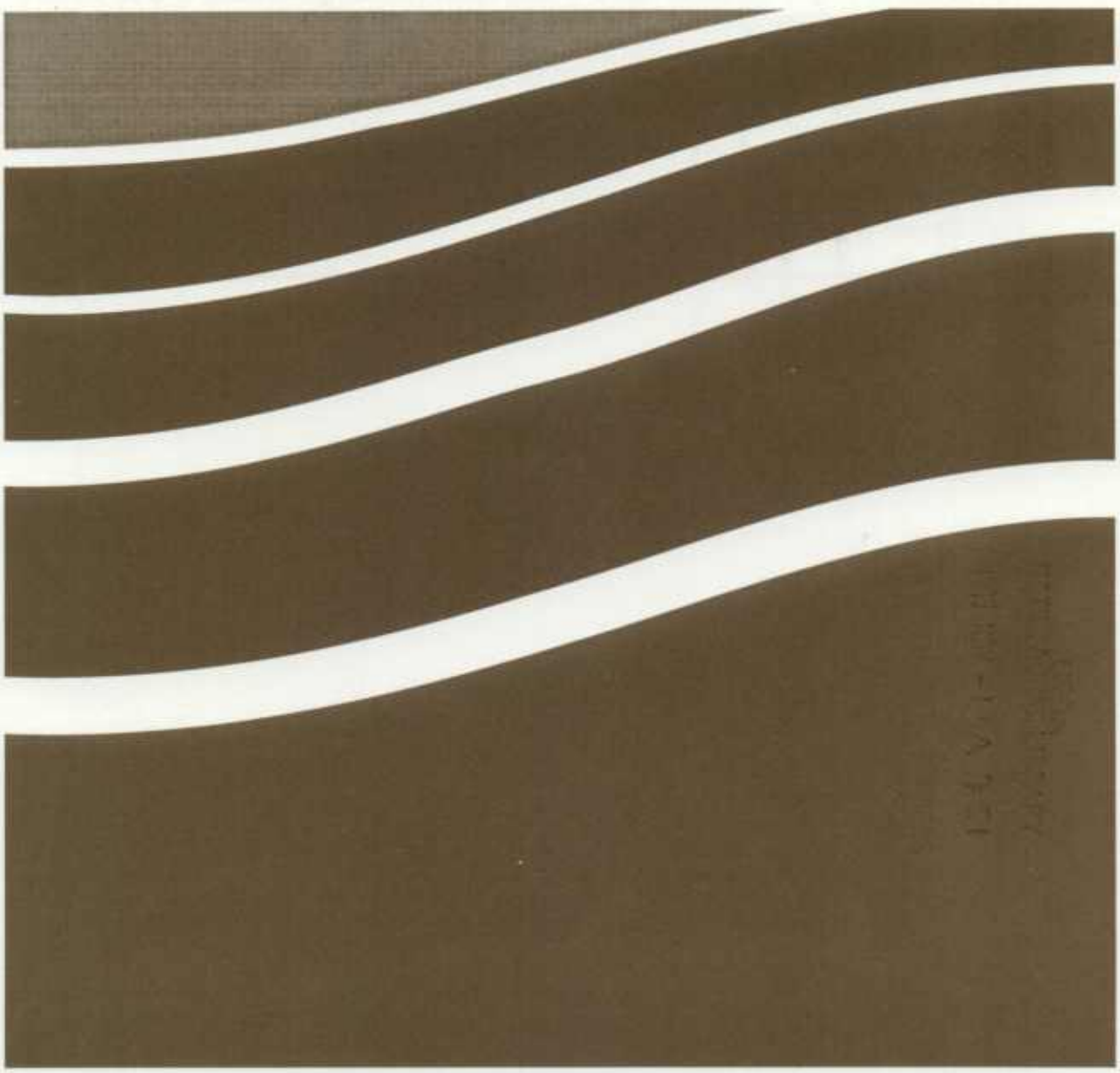
C. Tim Osborn



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Soil Erosion and Conservation in the United States: An Overview.
By Richard Magleby, Carmen Sandretto, William Crosswhite, C. Tim Osborn.
Natural Resources and Environment Division, Economic Research Service,
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Abstract

Soil erosion on agricultural land in the United States does not pose an immediate threat to the Nation's ability to produce food and fiber. However, erosion is impairing long-term soil productivity in some areas and is the largest contributor to nonpoint source pollution of the Nation's waterways. Over half of the soil erosion comes from slightly more than a quarter of total cropland acreage. New conservation programs since 1985 have specifically targeted these highly erodible lands, and erosion has significantly declined. Conservation and commodity programs are currently being coordinated to further conservation objectives. This report provides background information on soil use, erosion, and conservation policies and programs; summarizes assessments of economic and environmental effects of erosion; and discusses policies and programs as well as options for their improvement.

Keywords: Soil erosion, soil conservation, sediment, conservation programs

Acknowledgments

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Summary

Soil erosion in the United States does not pose an immediate threat to the Nation's ability to produce food and fiber, but it does reduce the productivity of some soils, and it also causes offsite damage. Soil productivity damages in the early 1980's were about $1-$3 billion annually, while water quality and dust damages likely were each several times higher. Agricultural lands are the principal source of eroded soil. Cropland contributes almost half of all eroded soil, with a quarter of this land, classified as highly erodible, providing over half of total cropland erosion. This report describes the various programs that have promoted soil conservation, providing the background information for assessment and analysis of this important facet of conservation.

Some factors hinder soil conservation. Among these are farmers' underestimation of their own farms' erosion problems, the uncertain cost and crop yield effects of conservation measures, and the agricultural program features which affect the type of crops grown. Farmers and ranchers often avoid adopting new practices if these are expensive, reduce profits, or show benefits only in the longer run or at off-site locations.

The report details current and proposed conservation measures. Possible actions to improve conservation programs include greater targeting of traditional assistance programs to critical lands, further removal of policy and program inconsistencies between commodity and conservation programs, expanded or continued retirement of critical lands, and increased use of compliance provisions or regulations.

Cropland erosion has declined over the past 50 years because of conservation efforts. In 1993, about one-third of total cropland in corn, soybeans, cotton, and wheat was in some kind of soil-conserving rotation. Recent incentive programs for protecting highly erodible lands include payments for retiring vulnerable lands from agricultural production and placing them under permanent vegetative cover. Leaving more crop residue on the soil surface has proved effective in conserving soil. Other techniques have included water management, contour farming, grassed waterways, and terraces.

Soil conservation programs have traditionally employed four major tools: technical assistance and extension education, voluntary participation in crop acreage diversion programs, cost-sharing for conservation measures, and various public works activities. In 1985, conservation compliance was introduced as a new major policy tool. Compliance requires farmers to meet minimum levels of conservation on highly erodible cropland by 1995 as an eligibility requirement for certain agricultural program payments. Though meeting the conservation provisions remains voluntary, farmers who want agricultural program payments have no choice but to comply.

Soil Erosion and Conservation in the United States

An Overview

Richard Magleby
Carmen Sandretto
William Crosswhite
C. Tim Osborn

Introduction

Soil erosion, the wearing away of soil by water, wind, and other forces, is a natural process that can be accelerated by human activities. This report provides background on the sources and extent of erosion in the United States and the policies and programs undertaken to reduce the problem on agricultural lands. It also summarizes the economic and environmental effects of erosion in the United States, the performance of policies and programs for reducing those effects, and some options for improving performance of conservation programs and delivery systems. The report uses materials prepared for the Organization for Economic Cooperation and Development in response to its request for information on soil erosion and conservation in the United States.

Erosion Levels and Conservation Activities

Soil erosion on agricultural land in the United States does not pose an immediate threat to the Nation's ability to produce food and fiber. However, erosion is impairing long-term soil productivity in some areas. Agricultural soil erosion is increasingly regarded as important to water quality and is the largest source of nonpoint pollutants in the Nation's waterways (USDA, SCS, RCA, 1989). Nonpoint pollutants that include sediment, nutrients, and chemicals come from diffuse sources that cannot be identified.

Causes and Types of Soil Erosion

The movement of water over the soil surface causes about three-fifths of the estimated erosion on U.S. land (table 1). Most often the water-caused erosion is

Table 1—Estimated erosion by type and source, contiguous United States, 1992

Type and source	Land area	Annual erosion[1]	Erosion/ acre/year
	Million acres	*Billion tons*	*Tons*
Sheet and rill			
Cropland	382	1.20	3.1
Pasture	126	.13	1.0
Range	399	.40	1.2
Forest[2]	395	.32	.8
Other rural non-Federal[2]	89	.47	5.3
Developed land[3,4]	92	.25	2.7
Water areas and Federal[5]	457	.44	1.0
Subtotal sheet and rill	1,940	3.21	1.7
Ephemeral	NA	NA	NA
Streambank and gully[5]	NA	.85	NA
Total water caused	1,940	4.06	2.1
Wind			
Cropland	382	.93	2.5
Pasture	126	.01	.1
Range	399	1.75	4.4
Forest	395	NA	NA
Other rural non-Federal[3]	89	.16	1.8
Developed land, water, and Federal	549	NA	NA
Total wind caused	1,940	2.85	1.5
Total all types	1,940	6.91	3.6

NA = Not available.
[1]Preliminary. [2]Erosion data not available for 1992. Assumed to be at the same per acre level as estimated in the 1987 National Resources Inventory. Includes lands in the Conservation Reserve Program. [3]Erosion data not available for 1992. Assumed to be the same total tonnage as estimated in the 1982 National Resources Inventory. [4]Includes roadsides and construction sites. [5]Not available for 1992. Assumed to be the same total tonnage as estimated in the 1977 National Resources Inventory (streambank was 0.55 million tons and gully was 0.30 million tons).
Source: USDA, Soil Conservation Service, 1982, 1984, 1994.

Types of Soil Erosion

In any given location, various types of erosion may be active and account for considerable soil loss. In other cases, only one or two of these erosion processes exist.

Erosion Caused by Water

Splash erosion occurs when raindrops break the bond between soil particles and move them a short distance.

Sheet erosion takes place when dislodged soil particles are moved by thin sheets of water flowing over the surface.

Rill erosion occurs when the surface flow of water establishes paths called rills, and flowing water readily detaches soil particles from their sides and bottoms.

Ephemeral or concentrated-flow erosion occurs when the topography of a landscape is such that rills tend to enlarge and join with others to form channels that are erased by tillage operations but often reform in the same location with each storm.

Gully erosion takes place when concentrated-flow erosion is allowed to continue over time and causes a gully to form. Gully erosion is difficult to control because soil is rapidly removed by water gushing over the "headcut" (uphill end) of the gully, by water scouring the gully's bottom, and by water removing soil material that has slumped from the gully's sidewalls.

Streambank erosion occurs when the steam flow causes caving and sloughing of streambanks.

Erosion Caused by Wind

Saltation or movement of fine and medium sand-sized soil particles begins when the wind velocity reaches about 13 miles per hour (mph) at 1 foot above the ground surface. The particles are lifted only a short distance into the air and the spinning action and their forward/downward movement give them extra power to dislodge other soil particles when they hit the ground. Saltation also destroys stable surface crusts, creating a condition more vulnerable to erosion, and the amount of soil moved increases with the width of the field. Saltation accounts for 50 to 80 percent of the total soil movement from wind erosion.

Suspension refers to the process by which very fine soil particles (the fertile organic matter and clay portions) are lifted from the surface by the impact of saltation, carried high into the air, and remain suspended in air for long distances. This "dust" can be blown hundreds of miles and is what most people associate with wind erosion.

Surface creep is the movement of larger (sand-sized) soil particles along the ground surface after being loosened by the impact of saltating particles, but such larger soil grains are too large to be lifted off the surface in most winds. These larger particles move in a rolling motion along the surface and can account for up to 25 percent of the soil moved by wind.

sheet and rill, but streambank and gully erosion are also significant (see box—"Types of Soil Erosion"—for definitions). Soil erosion by wind is predominantly limited to the Great Plains and certain areas in regional coastal plains.

Accelerated erosion results from agricultural, mining, and commercial and residential construction activities that disturb the soil or its protective cover. When farmers clear native woodland or plow meadow to grow cultivated crops, the soil is exposed to the erosive forces of water and wind. The overgrazing of range and pasture by livestock leads to the destruction of desirable native plant species and reduces this protection from erosion. Logging, mining, road construction, fire, and other disturbances can increase erosion and delay the recovery of the natural vegetative cover in the disturbed areas. In any given location, various types of water- and wind-caused erosion may be present and account for considerable soil loss.

Severity of Erosion in the United States

Soil erosion in the United States in 1992 averaged over 3.6 tons per acre per year, for a total of over 6.9 billion tons annually (table 1). The Nation's 382 million acres of cropland and 398 million acres of range, together about 40 percent of the land surface of the contiguous United States, accounted for about 62 percent of the total estimated erosion. Other non-Federal lands, mostly privately held pasture and forest, accounted for most of the remaining estimated erosion. However, no estimates exist for wind erosion on Federal lands or for ephemeral erosion, both of which could be significant.

Erosion occurs in all areas of the United States but is more concentrated in those regions where the percentage of total area in cropland is highest and where a larger proportion of the land is highly erodible (figs.

1 and 2). Susceptibility to erosion is the main limitation on more than half of the Nation's cropland.

Much of the erosion on U.S. cropland is concentrated on just a portion of the total cropland acreage. According to the 1992 National Resources Inventory, cropland classified as inherently highly erodible land (HEL) totaled 105 million acres, or barely over 27 percent of total cropland in 1992, but accounted for nearly 55 percent of total sheet, rill, and wind erosion on cropland that year (table 2). Erosion averaged about 11 tons/acre on HEL compared with 3.4 tons/acre on non-HEL. These 1992 results were an improvement over what existed in 1982 before new conservation programs in the 1985 Food Security Act further targeted HEL. In 1982, the nearly 30 percent of cropland classified as HEL accounted for 57 percent of cropland erosion, and averaged over 14 tons/acre erosion.

Sheet and rill erosion on cropland has been declining over the past 50 years (table 3). This type of erosion would probably have dropped even more since the 1960's except for an increase in the proportion of total cropland that has come into row crop production (such as corn, sorghum, tobacco, soybeans, cotton, peanuts, and potatoes), which is more erosive than close-grown crops (such as wheat, oats, barley and rice). Some 45 percent of total cropland was in row crops in 1992, compared with 37 percent in 1967. Average sheet and rill erosion per acre on pasture and range land has remained about the same since first estimated in 1982.

Wind erosion is also down from levels in the 1930's. Sharp drops occurred between 1987 and 1992 for both wind and sheet and rill erosion on cropland, largely because of new USDA conservation programs targeting highly erodible lands.

Erosion can decrease the land's productivity, increase fertilizer requirements, make tillage more difficult, and increase production costs. Sediment from eroding areas can clog rivers, restrict navigation, decrease reservoir capacity, increase water treatment costs, reduce recreation and scenic values, and increase the hazard and severity of flooding. Sediment and associated pollutants (plant nutrients and pesticides) also have detrimental effects on human health and on fish and wildlife populations and habitats (USDA, 1987). Wind-carried dust can damage growing crops and equipment and bury or interfere with buildings, fences, railroads, and other facilities (USDA, 1989a).

Soil Conservation Policies and Programs

USDA's conservation and water quality programs use one or more of the following policy tools:

(1) Onfarm technical assistance and extension education.

(2) Cost-sharing assistance for practice installation.

(3) Public works project activities.

(4) Rental and easement payments to take land out of production and place it into conservation uses.

(5) Conservation data and research aimed at evaluating and improving conservation practices and programs.

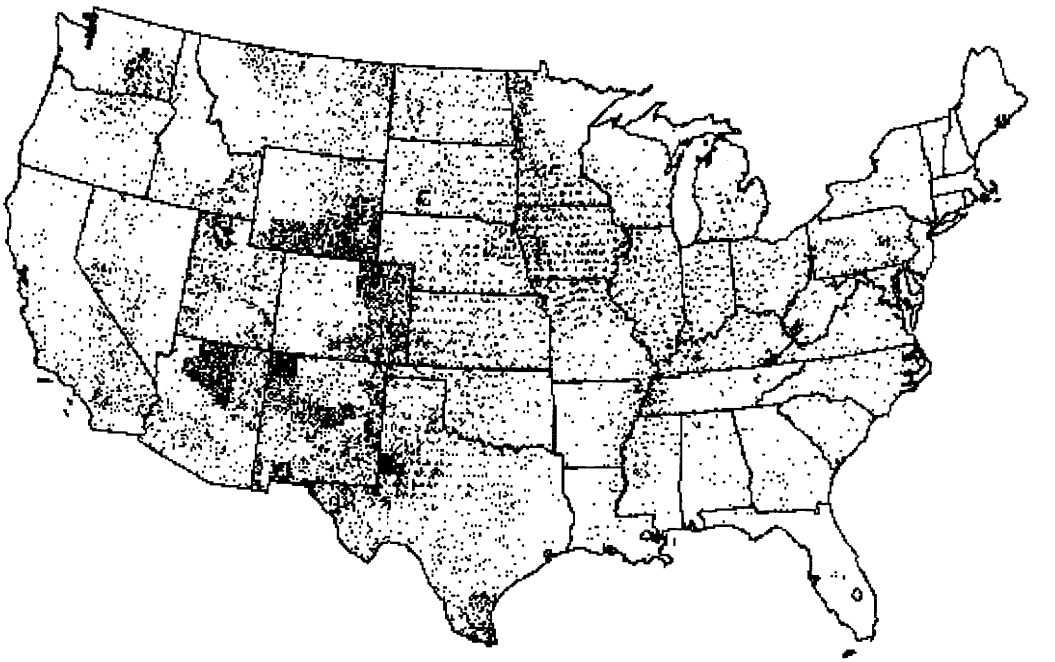
Table 2—U.S. cropland and cropland erosion by erodibility class, 1982 and 1992

Item and class	1982		1992	
	Million acres	*Percent*	*Million acres*	*Percent*
Cropland				
HEL	125	29.7	105	27.5
Non-HEL	296	70.3	277	72.5
Total	421	100.0	382	100.0
	Million tons		*Million tons*	
Cropland erosion				
HEL	1,801	57.0	1,160	54.5
Non-HEL	1,361	43.0	969	45.5
Total	3,162	100.0	2,129	100.0
		Tons/acre		
Cropland erosion/acre				
HEL	14.4		11.0	
Non-HEL	4.6		3.4	

HEL = Highly erodible lands in terms of inherent susceptibility of the soil to erosion, considering rainfall, soil characteristics, and slope length and steepness.

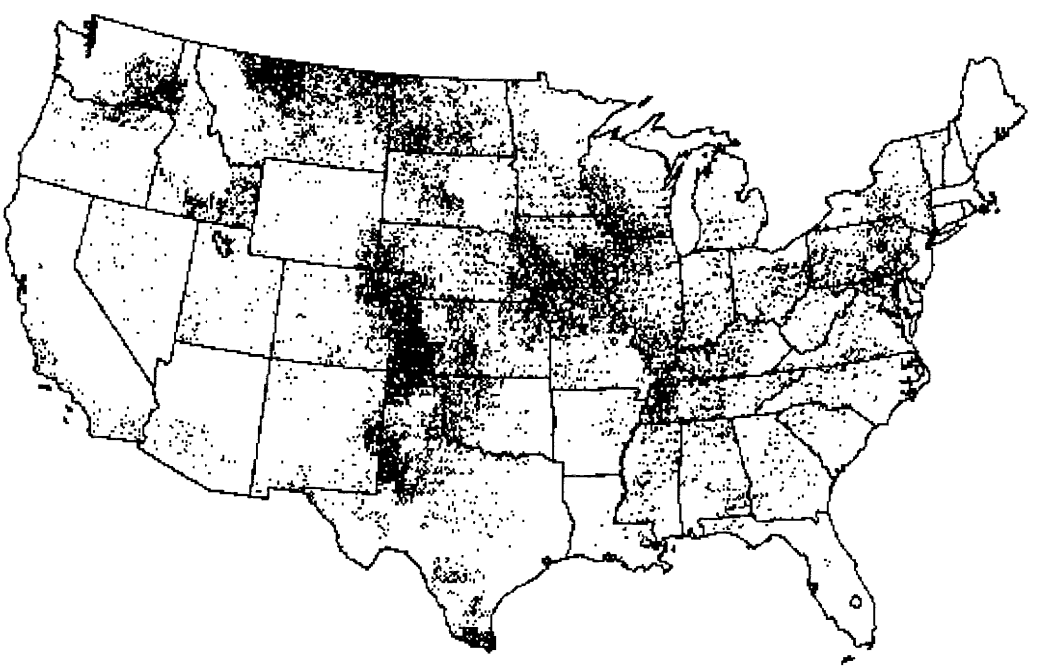
Source: USDA, Soil Conservation Service, 1992 National Resources Inventory.

Figure 1
Annual erosion, 1992



1 dot = 250,000 tons of sheet, rill, and wind erosion
Source: U.S. Department of Agriculture, Soil Conservation Service, 1992 National Resources Inventory.

Figure 2
Highly erodible cropland, 1992



1 dot = 5,000 cropland acres measuring 8 or more on USDA's Soil Conservation Service's erodibility index.
Source: U.S. Department of Agriculture, Soil Conservation Service, 1992 National Resources Inventory.

Table 3—Estimated acreage and erosion in the contiguous United States, selected years 1938-92

Item	1938	1967	1977	1982	1987	1992
			Million acres			
Acreage						
Cropland total	398.8[1]	438.2	413.3	421.0	406.6	382.3
Cropland in row crops	NA	160.4	203.3	195.9	158.6	177.8
			Percent			
Share in row crops	NA	37	49	46	39	45
			Million acres			
Pasture	NA	NA	NA	131.9	127.6	125.9
Range	NA	NA	NA	408.9	402.8	398.9
			Billion tons/year			
Total erosion						
Cropland:						
Sheet and rill	NA	2.60[2]	1.93	1.71	1.50	1.20
Wind	NA	NA	0.89	1.42	1.30	0.93
Subtotal	3.56[3]	NA	NA	3.13	2.80	2.13
Pasture:						
Sheet and rill[4]	NA	NA	NA	1.45	1.28	1.26
Wind[4]	NA	NA	NA	0.13	0.13	0.13
Range:						
Sheet and rill[4]	NA	NA	NA	0.49	0.48	0.48
Wind[4]	NA	NA	NA	1.92	1.77	1.76
Total cropland, pasture, range	NA	NA	NA	7.12	6.46	5.76
			Tons/acre/year			
Erosion per acre						
Cropland:						
Sheet and rill	NA	5.9	4.7	4.1	3.7	3.1
Wind	NA	NA	5.3	3.3	3.2	2.4
Subtotal	8.9[5]	NA	NA	7.4	6.9	5.5
Pasture:						
Sheet and rill	NA	NA	NA	1.1	1.0	1.0
Wind	NA	NA	NA	0.1	0.1	0.1
Range:						
Sheet and rill	NA	NA	NA	1.2	1.2	1.2
Wind	NA	NA	NA	4.7	4.4	4.4

NA = Not available.

[1]Based on 1939 census estimate of cropland. [2]Kimberlin (1976), based on 1967 Conservation Needs Inventory. [3]This estimate by Bennett and Lowdermilk (1938) is based on extrapolation of experimental plot data and is less reliable than later statistical survey estimates. [4]Preliminary. Based on multiplying published per acre erosion estimates times acreage. [5]Based on dividing the sum of sheet, rill, and wind erosion by the 1939 census estimate of cropland acres.

Sources: USDA, Soil Conservation Service, National Resources Inventories of 1977, 1982, 1987, and 1992 except as noted.

(6) Compliance provisions that require the implementation of specified conservation practices or the avoidance of certain land use changes if the operator wishes to be eligible for USDA agricultural program payments.

The technical assistance/education and cost-sharing approaches are components in most of USDA's soil conservation and water quality programs. Public works project activities are used for larger scale watershed protection and flood prevention activities. The fourth approach, payments to take land out of production and place it into conservation uses, has been used at various times in the past, such as the Soil Bank program of the 1950's, and is reflected in the current Conservation Reserve Program (CRP) and Wetlands Reserve Program (WRP). Along with conservation, the CRP has a second objective of reducing surplus production. The fifth approach of data collection and research is an essential complement to the other approaches, rather

than a viable alternative by itself. The sixth and newest approach to conservation, compliance, originated in the 1985 Food Security Act with the conservation compliance, sodbuster, and swampbuster provisions and represents a significant policy shift (Heimlich, 1991). While meeting the conservation provisions remains voluntary, farmers who want to receive certain agricultural program payments have no other choice (Crosswhite and Sandretto, 1991).

Evolution of Federal Conservation Programs

For most of the 60-year history of Federal conservation programs, emphasis was placed on the onfarm productivity benefits of reducing erosion. However, an increasing interest in conservation and environmental policies caused a shift in the 1970's from improving soil productivity and maintaining farm income toward reducing the off-farm effects of agriculture on the environment (fig. 3).

Federal involvement in conservation began in the 1930's with the authorization of a study to examine the causes of erosion and to recommend methods for its control. The Soil Conservation Act of 1935 established USDA's Soil Conservation Service (SCS)—renamed the Natural Resources Conservation Service (NRCS) in 1994—and SCS' Conservation Technical Assistance (CTA) program. The act authorized SCS to aid farmers in planning and installing approved conservation measures to protect agricultural land from soil erosion. The CTA program was followed in 1936 by the creation of the Agricultural Conservation Program (ACP), which provided cost-sharing assistance to farmers for implementing conservation practices (Rasmussen, 1982). From these initial efforts, a comprehensive set of research, education, and financial and technical assistance programs has evolved to support conservation (see box—"USDA Conservation Programs Prior to 1985").

During periods of surplus production, temporary conservation and cropland diversion programs were used to idle program crop acreage to help support farm income. For example, the ACP placed an average of 36 million acres of cropland in permanent cover between 1936 and 1942 to reduce production of surplus crops, and at the same time on other lands provided farmers cost-sharing and technical assistance to carry out other soil conservation measures to reduce both water and wind erosion. In the 1950's and 1960's, the Great Plains Conservation Program, Small Watershed Program, and Resource Conservation and Development Program were established to address regional concerns, flood protection, and rural development issues.

The Agricultural Act of 1956 established the two-part Soil Bank. The first part, the Acreage Reserve Program, paid farmers to annually reduce acreage planted to surplus commodities. This program represented a notable shift from total reliance on commodity loans and non-targeted land diversion. The second part, the Conservation Reserve Program, provided for 3- to 10-year contracts for retirement of any land designated by the farmer without regard to specific resource conditions. In return, farmers received annual rental payments and 80 percent of the cost of establishing permanent vegetative cover. Farmers could enroll as much of their land as they wished and received a 10-percent rental bonus for whole-farm retirement (Heimlich, 1991). Long-term land retirement was intended to provide conservation and resource protection for soils, water, forests, and wildlife. The Acreage Reserve Program ended in 1958 and enrollment in the Conservation Reserve ceased in 1961, but program crop acreage placed in the long-term Conservation Reserve remained idle into the early 1970's.

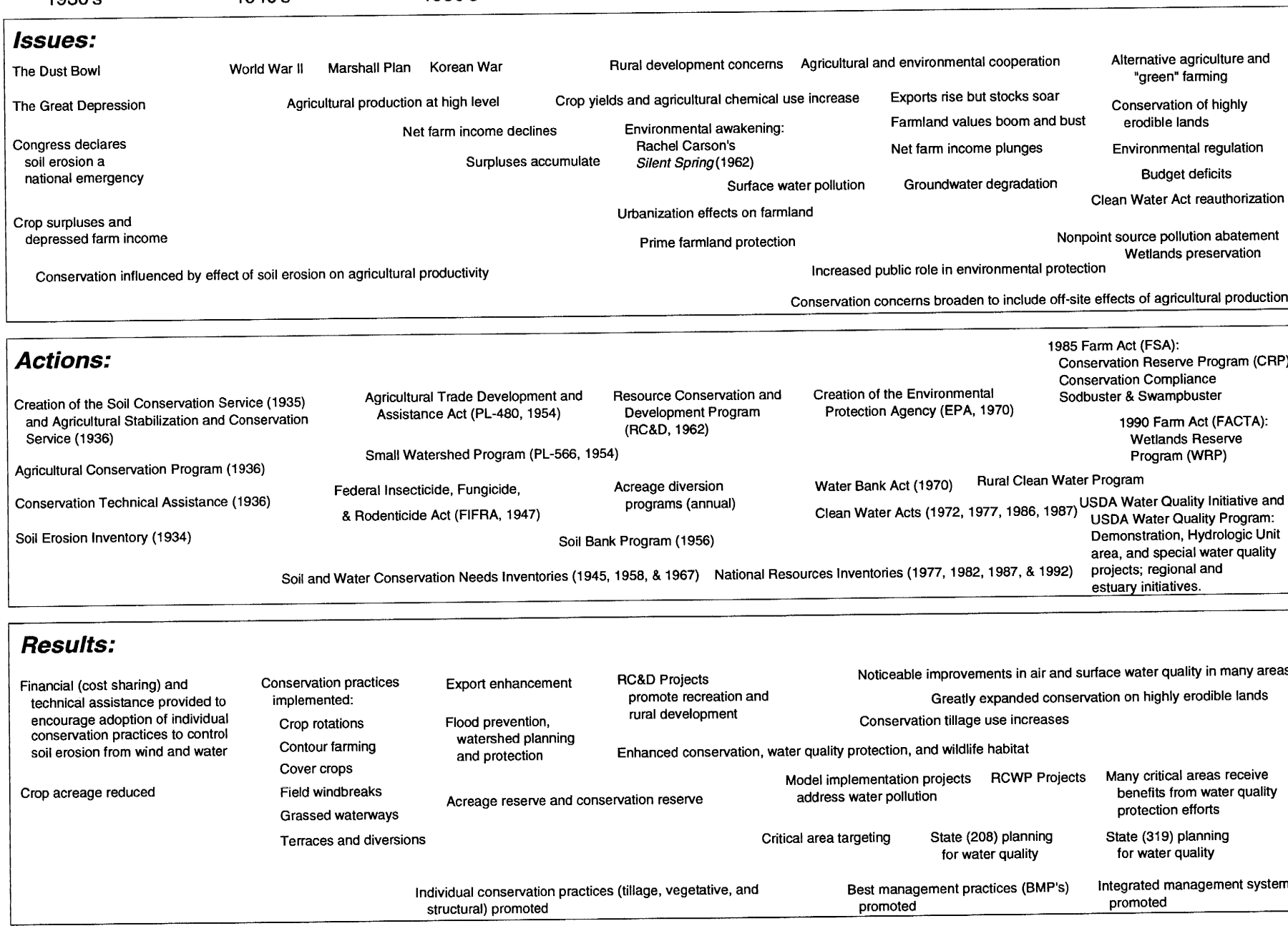
During the 1970's and 1980's, Federal conservation policy increasingly stressed farming methods to mitigate the off-farm effects of sediment and other pollutants generated by agriculture. Parts of the ACP cost-sharing and SCS technical assistance programs were directed toward water quality projects and similarly targeted additional funding derived from the Rural Clean Water Program begun in 1980. Within this time frame, an evolution took place from implementing individual conservation practices to implementing multiple best management practices (BMP's) and recently to implementing integrated resource management systems as the means of achieving desired environmental results.

In 1985, conservation programs took a decided turn toward greater targeting and more restrictions on land use. The Food Security Act of 1985 established the Conservation Reserve Program (CRP) to deal with both continuing commodity surpluses and resource protection issues. Under the CRP, land is retired from production for at least 10 years. But, unlike the earlier Soil Bank and Conservation Reserve programs which permitted enrollment of any land the farmer designated, the new CRP targeted highly erodible and/or environmentally sensitive cropland. The act also provided for two other new provisions targeted to highly erodible lands, conservation compliance and sodbuster, and stipulated that farmers of such lands who did not implement approved conservation plans would lose eligibility for USDA program benefits (see box—"USDA Conservation Programs New Since 1985").

The Food, Agriculture, Conservation, and Trade Act of 1990 further reshaped and sharpened the environ-

Figure 3

The evolution of conservation, resource protection, and water quality efforts



USDA Conservation Programs Prior to 1985

Financial, Technical, and Extension Assistance Programs

These programs provide assistance to farmers, ranchers, local organizations, and multicounty areas to implement practices to achieve soil and water conservation, water quality improvement, timber stand improvement, recreation, and rural development.

Agricultural Conservation Program (ACP), initiated in 1936, provides financial assistance to carry out approved conservation and environmental protection practices on agricultural land. Cost-share payments to a given farmer cannot exceed $3,500 per year on 1-year agreements, and cannot average over $3,500 per year on multiyear agreements.

Colorado River Basin Salinity Control Program (CRBSC), initiated in 1974 and amended in 1984, establishes a voluntary onfarm cooperative salinity control program within the USDA and provides for cost sharing of onfarm improvements.

Conservation Loans and Easements. Since 1946, USDA has provided loans to farmers and associations of farmers for soil and water conservation, pollution abatement, and building or improving water systems that serve several farms. May acquire 50-year conservation easements as a means of helping farmers reduce loan amounts.

Conservation Technical Assistance (CTA), initiated in 1936, provides technical assistance by the Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), through Conservation Districts to farmers for planning and implementing soil and water conservation and water quality practices.

Emergency Conservation Program, initiated in 1978, provides financial assistance to farmers in rehabilitating cropland damaged by natural disasters.

Extension Education, initiated in 1923, provides information and recommendations on farm management, crop production, and soil and water quality practices to land owners and operators in cooperation with State and local offices of USDA agencies and conservation districts.

Forest Management. The Forest Service (FS), established in 1905, provides technical assistance to State and private owners of forested lands for implementing timber stand improvement and conservation.

Forestry Incentives Program (FIP), initiated in 1975 as a separate program, provides cost sharing up to 65 percent for tree planting and timber stand improvement for private forest lands of no more than 1,000 acres.

Great Plains Conservation Program (GPCP), initiated in 1957, provides technical and financial assistance in Great Plains States for conservation treatment on entire operating units. Financial cost-share assistance limited to $35,000 per farmer contract.

Resource Conservation and Development Program (RC&D), initiated in 1962, assists multicounty areas in enhancing conservation, water quality, wildlife habitat, recreation, and rural development.

Rural Clean Water Program, initiated in 1980 and set to end in 1995, is an experimental program that has been implemented in 21 selected areas. It provides cost sharing and technical assistance to farmers voluntarily implementing best management practices to improve water quality. Cost share limited to $50,000 per farm.

Small Watershed Program (PL-566), initiated in 1954, assists local organizations in flood prevention, watershed protection, and water management. Part of this effort involves establishment of measures to reduce erosion, sedimentation, and runoff.

Water Bank Program, initiated in 1970, provides annual payments for preserving wetlands in important migratory waterfowl nesting, breeding, or feeding areas.

Data and Research Programs

Agricultural Research Service (ARS) conducts research on new and alternative crops and agricultural technology to reduce agriculture's adverse effects on soil and water.

Extension Service (now part of the Cooperative State Research, Education, and Extension Service (CSREES)) coordinates conservation and water quality research conducted by State agricultural experiment stations and land-grant universities. This agency allocates and administers funds appropriated for special and competitive grants for water quality research.

Economic Research Service (ERS) estimates economic effects of existing and alternative policies, programs, and technology for preserving and improving soil and water quality. With **National Agricultural Statistics Service (NASS)**, collects data on farm chemical use, agricultural practices, and costs and returns.

Forest Service (FS) conducts research on environmental and economic effects of alternative forest management policies, programs, and practices.

Soil Conservation Service (now the Natural Resources Conservation Service (NRCS)) conducts river basin studies, soil surveys, snow surveys, National Resources Inventories, and supports plant materials centers.

mental targeting of conservation programs. The act includes revised program rules for operating CRP during 1991-95, a new Wetlands Reserve Program (WRP), an agricultural Water Quality Incentive Program (WQIP), an Environmental Easement Program, and revised conservation compliance and incentive features. However, appropriations for the WRP and WQIP have been less than what was authorized, and no funds have been yet appropriated for the Environmental Easement Program.

The Budget Reconciliation Act of 1990 also provided a planting flexibility provision to allow farmers a range of crop choices on a portion of program crop acreage base. The latter allows increased use of crop rotations which may have sustainable (usually erosion-reducing) characteristics without loss of crop acreage base (Osborn, 1991).

USDA Conservation Expenditures

Between 1986 and 1994, spending on conservation activities by USDA and State and local governments increased steadily (fig. 4); expenditures were nearly $3.7 billion in 1993 and were an estimated $4.1 billion in 1994. The bulk of these expenditures were related to soil conservation, but an exact breakdown is not available.

Since 1986, the mix of USDA expenditures across the six policy approaches has changed. Rental and easement payments accounted for a small share of total conservation efforts prior to the CRP, but are now the largest category, accounting for over half of USDA conservation expenditures in 1994 (fig. 4; table 4). Most rental payments were for land enrolled in the CRP. Easement payments supported land accepted into the 1990 Wetlands Reserve Program.

Technical assistance and education expenditures of $825 million in 1994 accounted for just under one-fourth of the USDA total for conservation purposes. However, the share was much lower than prior to 1988, when CRP rental payments became the largest single component of USDA conservation expenditures.

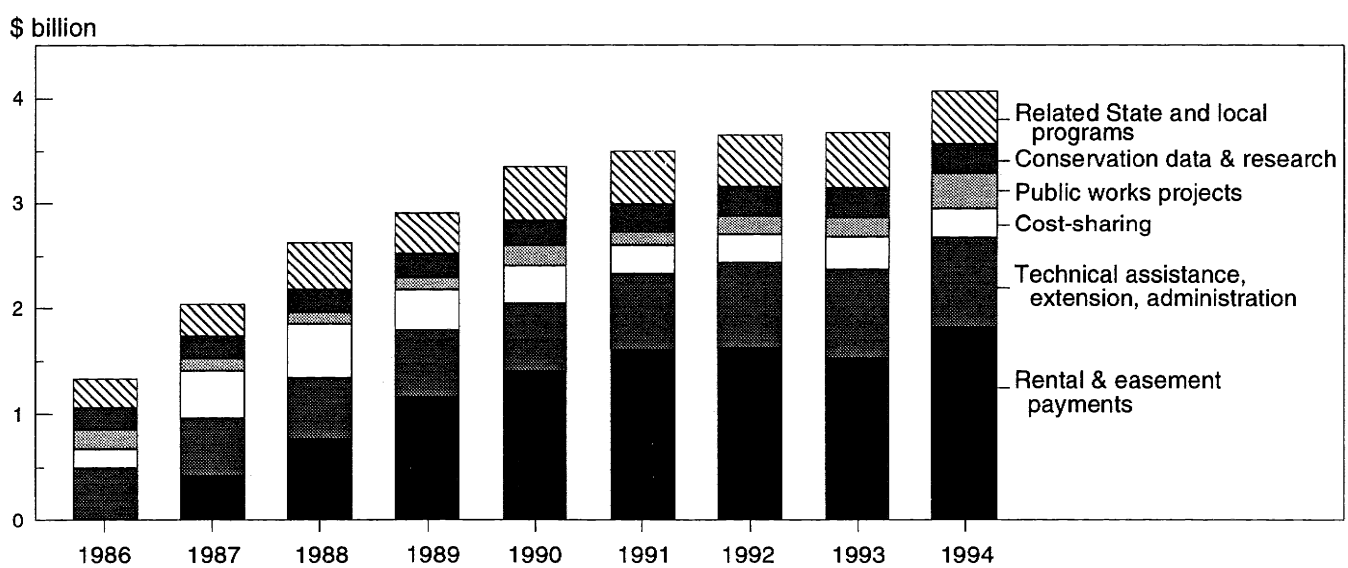
Higher expenditures for public works activities in 1994, at about 10 percent of USDA spending, reflect emergency measures required by the 1993 Midwest flood. Cost-sharing for installation of practices, which accounted for only 8 percent of USDA spending, was at about the same level as conservation data collection and research.

The President's budget for 1995 shows reductions in all categories except rental and easement payments, with deep cuts in cost-sharing and public works activities. The budgeted increase in rental and easement payments is for land expected to go into the new Wetlands Reserve Program established in 1990.

Non-USDA Federal Conservation Programs

Some other Federal (non-USDA) programs also have provisions or aspects that deal with soil erosion (See box—Non-USDA Federal Programs Affecting Soil Conservation). Section 319 of the Water Quality Act of 1987 requires States to assess water quality problems

Figure 4
Conservation expenditures by USDA and related State and local programs, 1986-94



Source: USDA, Office of Budget and Program Analysis data.

USDA Conservation Programs New Since 1985

These new programs resulted from the Food Security Act of 1985; the Food, Agriculture, Conservation, and Trade Act of 1990; the USDA Initiative on Water Quality; and a USDA initiative on residue management.

Farm Act Provisions

The **conservation compliance** provision requires farmers with highly erodible cropland to have had an approved conservation plan by Jan. 1, 1990. The plan must be fully implemented by Jan. 1, 1995, to maintain eligibility for USDA program benefits.

The **Sodbuster provision** provides that farmers who convert highly erodible land to agricultural commodity production must have an approved conservation system in place, to be eligible for USDA program benefits.

The **Swampbuster provision** requires that before farmers convert a wetland to commodity production, they must obtain a USDA determination that conversion would have only a minimal effect on wetland hydrology and biology, to remain eligible for USDA program benefits.

Potential penalties for violating the conservation compliance, sodbuster, and swampbuster provisions include loss of eligibility for commodity price- and income-support payments, crop insurance and disaster payments, and assistance under USDA conservation programs.

The **Conservation Reserve Program** (CRP) provides for USDA to enter into 10-15 year agreements through 1995 with owners and operators to remove highly erodible and other environmentally sensitive cropland from production. Lands in the CRP must have protective cover and cannot be farmed, grazed, or otherwise used for agricultural production except in certain declared emergencies. Owners or operators of the lands placed into the CRP receive cost sharing to establish protective cover and annual rental payments based on a bid and acceptance procedure. Special incentives are provided for planting hardwood trees and converting grass to tree cover. Crop acreage bases, quotas, and allotments on CRP lands are preserved as long as the owner or operator continues to keep the land in the appropriate conserving uses.

Wetlands Reserve Program (WRP) provides for USDA to solicit bids from landowners to place into the reserve cropped hydric soils, non-cropped wetlands (such as Water Bank lands), riparian corridors, and critical wildlife habitat. Participants must agree to long-term easements on enrolled land (30 years or more or the maximum duration allowed under applicable State laws); must implement a wetland easement conservation plan that restores and protects the wetland's functional values; and must give up any existing cropland base and allotment history on enrolled land. In return, participants receive payments and cost sharing up to the fair market value of the land. Economic uses of the restored wetlands, such as hunting, fishing, managed timber harvest, or periodic haying and grazing, are allowed to help reduce the cost of acquiring easements.

Water Quality Incentives Program (WQIP) provides for USDA to enter into 3- to 5-year agreements with owners and operators of certain critical lands for developing and implementing plans to protect water quality. Eligible lands include wellhead protection areas (land within 1,000 feet of a public well), areas of shallow Karst topography where sinkholes convey runoff water directly into ground water, critical cropland areas identified under Section 319 of the Water Quality Act of 1987, and other environmentally sensitive areas.

Participants must implement a USDA-approved water quality protection plan; report use of nutrients, pesticides, and animal waste; and supply production evidence and the results of well tests, soil tests, and annual tissue tests for each year of the agreement. Unlike most CRP contracts and WRP easements, these agreements do not preclude commodity production on enrolled acreage. In return, participants will receive an annual incentive payment not to exceed $3,500 per participant per year. Cost sharing is also available if a farmer elects to preserve wetlands or enhance wildlife habitat. During the agreement period, producers also receive program yield and base acreage protection.

Water Quality Initiative/ Program

Activities begun in 1989 under the Water Quality Initiative are being continued as USDA's Water Quality Program. Education and technical assistance have been directed to 16 selected demonstration projects, 74 hydrologic unit areas, and other special water quality projects to accelerate the adoption of water quality protection practices by farmers. ACP cost sharing to assist farmers in implementing selected practices is also being targeted to these projects. Special research and development efforts are aimed at developing and identifying technology and production systems that reduce the environmental effects of agricultural chemical use and are economical for farmers to adopt. New database development and evaluation activities include collection and analysis of survey data from farmers on pesticide and nutrient use on major crops and analysis of the economic and environmental effects of water quality practices and programs.

Residue Management Initiative

The residue management initiative was an interagency effort to accelerate assistance to land users to help them apply conservation plans and meet the conservation compliance provisions of the 1985 and 1990 Farm Acts. Over two-thirds of the conservation plans identified management of crop residue as the key component needed to achieve the January 1, 1995, compliance goal. The initiative's three components were: a residue management marketing program, an information delivery system, and a technical assistance and technology delivery program. Each component was targeted toward the delivery of timely information and needed technical assistance to help producers implement their conservation plans and maintain their eligibility for USDA program benefits. It was designed to build improved technical expertise at the State, area, and field office levels to help land users better understand the conservation compliance provisions.

Table 4—USDA conservation expenditures, by activity and program, fiscal 1983-95[1]

Activity/program	1983	1985	1987	1989	1991	1992	1993	1994 estimate	1995 enacted
					Million dollars				
1. Technical assistance, extension, and administration									
Natural Resources Conservation Service (NRCS) programs—									
Conservation Technical Assistance (CTA)[2]	276.9	302.0	332.0	386.7	426.5	477.9	515.2	502.6	500.5
Great Plains Conservation Program (GPCP)	9.1	9.1	9.1	8.2	8.3	9.1	8.9	9.3	8.9
Resource Conservation & Development (RC&D)	16.3	17.8	17.8	18.4	24.2	26.0	29.9	28.4	28.8
Watershed Protection / Flood Prevention	101.6	76.9	68.1	65.9	70.3	74.3	80.4	83.5	55.9
Small Watershed Program (planning)	8.9	8.9	8.7	8.7	9.2	9.5	9.5	10.9	10.5
Subtotal NRCS	412.8	414.7	435.7	487.9	538.5	596.8	643.9	634.7	604.6
Consolidated Farm Service Agency (CFSA) programs—									
Agricultural Conservation Program (ACP)[2]	11.0	11.2	9.3	10.1	10.6	10.8	11.2	9.7	5.0
Colorado River Salinity Control Program	0.0	0.0	1.4	2.0	5.9	5.9	5.5	4.9	1.5
Conservation Reserve Program (CRP)	0.0	0.0	21.9	27.9	5.7	11.4	8.9	4.7	0.0
Emergency Conservation Program (ECP)	0.1	0.6	0.1	0.4	0.5	0.8	1.5	1.0	0.0
Forestry Incentives Program (FIP)	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.3	0.0
Rural Clean Water Program (RCWP)	-0.9	0.0	2.5	-0.7	0.8	0.4	0.0	0.0	0.0
Water Bank Program (WBP)	0.0	0.0	0.0	0.0	0.7	1.1	1.1	0.4	0.0
Wetlands Reserve Program (WRP)[3]	0.0	0.0	0.0	0.0	0.0	0.0	4.9	3.5	7.7
CFSA salaries & exp., conservation	32.8	33.1	47.6	62.4	73.8	72.6	65.3	67.6	62.8
Subtotal CFSA	44.3	46.1	84.0	103.3	99.2	104.2	99.6	93.1	77.0
Extension Service (ES) conservation activities[2]	15.9	16.4	15.7	19.8	29.4	31.1	31.1	33.8	33.8
Forest Service (FS) programs—									
Forest Stewardship Program	10.3	6.9	7.0	6.8	22.6	23.9	23.3	25.8	33.1
Other Cooperative Forest Conservation	4.1	2.9	3.0	6.2	24.8	32.6	37.4	36.7	35.0
Subtotal FS	14.4	9.8	10.0	13.0	47.4	56.5	60.7	62.5	68.1
Subtotal tech. assistance, exten. & administration	487.4	487.0	545.4	624.0	714.5	788.6	835.3	824.1	783.5
2. Cost-sharing for practice installation									
CFSA programs—									
Agricultural Conservation Program (ACP)[2]	176.5	179.2	172.6	174.0	171.6	179.1	182.8	183.0	95.0
Colorado River Salinity Control Program	0.0	0.0	2.5	3.4	8.9	8.8	8.2	8.2	3.0
Conservation Reserve Program (CRP)	0.0	0.0	245.6	182.3	40.9	39.3	32.0	14.1	4.3
Emergency Conservation Program (ECP)	13.9	4.9	5.3	6.1	8.8	10.3	42.0	24.0	0.0
Forestry Incentives Program (FIP)	11.3	11.5	10.7	11.0	12.4	11.5	11.2	11.5	6.0
Rural Clean Water Program (RCWP)	2.5	1.9	0.0	0.8	0.1	0.0	0.0	0.0	0.0
Wetlands Reserve Program (WRP)[3]	0.0	0.0	0.0	0.0	0.0	0.0	0.1	5.3	7.0
Subtotal CFSA	204.2	197.5	436.7	377.6	242.7	249.0	276.3	246.1	115.3
FS Stewardship Incentive Program (SIP)	0.0	0.0	0.0	0.0	19.9	0.8	17.8	17.9	18.3
NRCS Great Plains Conservation Program (GPCP)	12.2	12.5	11.4	12.2	16.4	16.2	16.4	16.4	6.3
Subtotal cost-sharing	216.4	210.0	448.1	389.8	279.0	266.0	310.5	280.4	139.9
3. Public works project activities (NRCS)									
Emergency Watershed Protection	22.5	5.0	14.8	10.0	20.0	70.0	73.1	248.0	125.0
Flood Prevention Operations	22.7	13.9	11.5	12.8	12.8	21.4	23.8	22.9	0.0
Resource Conservation and Development (RC&D)	14.4	8.5	7.2	6.7	5.7	6.5	2.6	4.6	4.0
Small Watershed Program (operations)	160.6	88.0	82.7	83.7	82.6	89.6	101.3	106.9	14.1
Subtotal NRCS public works projects	220.2	115.4	116.2	113.2	121.1	187.5	200.8	382.4	143.1
4. Rental and easement payments (CFSA)									
Conservation Reserve Program (CRP)	0.0	0.0	410.0	1,162.1	1,590.1	1,612.5	1,510.0	1,729.2	1,739.0
Water Bank Program (WBP)	8.8	8.8	8.4	9.0	13.1	17.1	17.1	7.4	0.0
Wetlands Reserve Program (WRP)	0.0	0.0	0.0	0.0	0.0	0.0	4.4	47.3	63.0
Subtotal rental and easement payments	8.8	8.8	418.4	1,171.1	1,603.2	1,629.6	1,531.5	1,783.9	1,802.0
5. Conservation data and research									
Natural Resources Conservation Service	75.5	77.8	79.7	90.8	96.0	99.6	99.6	102.1	99.5
Agricultural Research Service	63.5	63.7	59.3	65.9	73.6	73.9	74.3	76.7	76.0
Cooperative State Research, Educ., & Ext. Service	27.9	32.8	31.0	34.5	50.6	49.7	51.7	51.2	43.2
Economic Research Service	5.0	5.4	4.0	3.0	5.5	5.8	6.3	5.0	4.0
National Agricultural Library (water quality)	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3
Forest Service (forest environment research)	19.7	20.3	28.2	31.1	40.7	39.0	41.8	42.0	42.2
Subtotal conservation data and research	191.6	200.0	202.2	225.3	266.7	268.3	274.0	277.3	265.2
6. Conservation compliance and sodbuster (CFSA & NRCS) (expenditures are included in technical assistance and administration)									
USDA total	1,124.4	1,021.2	1,730.3	2,523.4	2,984.5	3,140.0	3,152.1	3,548.1	3,133.7

[1] Based on data from USDA, Office of Budget and Program Analysis.
[2] Includes expenditures for Water Quality Incentives Projects and other activities of the Water Quality Program.
[3] Shifted to NRCS in 1995.

(sediment from cropland erosion is a predominant or contributing factor in many areas) and to develop plans for managing the problems. Also the act authorizes a program for implementing the Section 319 plans with funds moving through the Environmental Protection Agency to the States, but appropriations so far have permitted only a small-scale program. Under its Water Quality Initiative, however, USDA has selected 74 areas identified in States' Section 319 assessments for special targeting of education, technical, and financial

Non-USDA Federal Programs Affecting Soil Conservation

EPA-Administered Programs

The Clean Water Act is the Nation's most important water quality protection law. Originally passed in 1972 and administered by the Environmental Protection Agency (EPA), the Act's goal is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The Act contains a number of provisions that affect soil conservation.

The Clean Lakes Program, reauthorized by Section 314 of the Clean Water Act, authorizes EPA grants to States for lake classification surveys, diagnostic/feasibility studies, and for projects to implement lake restoration and protection. To remain eligible for grants, a State must submit a biannual report to the EPA on the status of lakes and establish a clean lakes demonstration program. States typically rely on Section 319 nonpoint source management programs and USDA programs to control sediment and other agricultural pollutants entering lakes. States have relied on farmers voluntarily adopting alternative management measures in areas surrounding designated lakes to reduce agricultural runoff.

The Nonpoint Source Program, established by Section 319 of the Clean Water Act, requires States and U.S. territories to file assessment reports with EPA, identifying navigable waters that cannot attain water quality standards without reducing nonpoint source pollution. Management plans must then be developed to reduce nonpoint source pollution. All States now have EPA-approved plans. The Act authorizes up to $400 million annually in grants to States for developing and promoting these plans, with $50 million awarded in fiscal 1992. The funds, however, cannot be used to provide cost-sharing to individual landowners. To the extent that States require and enforce reductions in agricultural nonpoint source pollution, the program could impose significant costs on the agricultural sector.

The National Estuary Program, established by Section 320 of the Clean Water Act, provides for the identification of nationally significant estuaries that are threatened by pollution; for preparation of conservation and management plans; and for Federal grants to State, interstate, and regional water pollution control agencies to implement the plans. So far, 21 estuaries have been designated (fig. 5). USDA is providing accelerated technical and financial assistance to farmers in designated areas to help States carry out their estuary management plans.

Coastal Nonpoint Pollution Control Program, established by 1990 amendments to the Coastal Zone Management Act and administered jointly by the National Oceanic and Atmospheric Administration and EPA, requires that coastal zone States develop programs and implement management measures to restore and protect coastal waters, in conformity with EPA guidance. Management measures for agriculture are specified for erosion and sediment, nutrients, pesticides, grazing, and animal waste. The State program must implement these management measures by whatever means necessary, including regulation. So far the program has relied upon voluntary participation.

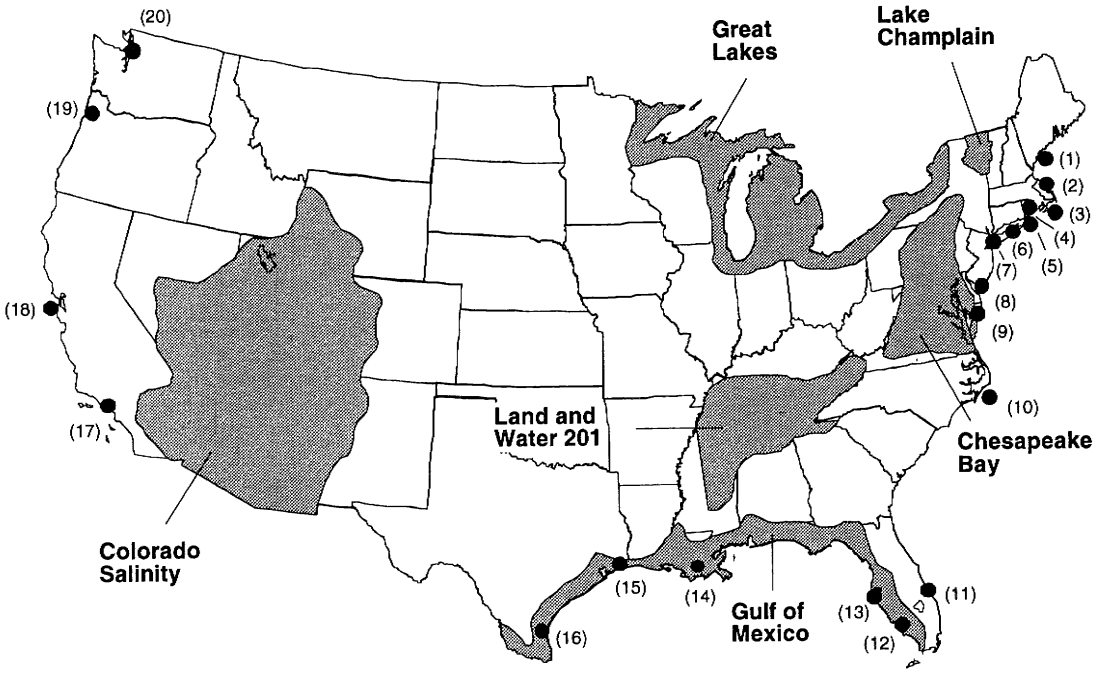
Regional programs exist in six areas of the U.S. as cooperative Federal/State efforts (fig. 5). Each program is managed by a regional authority consisting of EPA, other Federal agencies, and appropriate State agencies. Under USDA's Water Quality Program, the Natural Resources Conservation Service has accelerated technical assistance to landowners in the six regions, and the Consolidated Farm Service Agency has provided cost-share financial assistance to further implementation of conservation and water quality measures.

Other Programs

The Dredge and Fill Permit Program, established by Section 404 of the Clean Water Act and administered by the U.S. Army Corps of Engineers, regulates dredging, filling, and other alterations of waters and wetlands, including wetlands owned by farmers. Recently, USDA was given authority to make wetlands determinations on agricultural land.

Range Improvements, including rehabilitation and protection, are undertaken by the Bureau of Land Management, U.S. Department of the Interior, with a percentage of receipts from grazing of livestock on the public lands.

Figure 5
Estuary and regional programs for water quality, 1993



• Estuaries of national significance: (1) Casco Bay, (2) Massachusetts Bay, (3) Buzzards Bay, (4) Narragansett Bay, (5) Peconic Bay, (6) Long Island Sound, (7) New York-New Jersey Harbor, (8) Delaware Bay, (9) Delaware Inland Bays, (10) Albemarle-Pamlico Sound, (11) Indian River Lagoon, (12) Sarasota Bay, (13) Tampa Bay, (14) Barrataria-Terrebonne Estuary, (15) Galveston Bay, (16) Corpus Christi Bay, (17) Santa Monica Bay, (18) San Francisco Bay, (19) Tillamook Bay, (20) Puget Sound, (21) San Juan Bay (Puerto Rico, not pictured).

Technical assistance provided by the Natural Resources Conservation Service.

assistance to farmers to promote implementation of improved practices.

The Coastal Nonpoint Pollution Control Program, established in 1990, is another non-USDA program with potentially significant effects on soil erosion. The Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, are responsible for enforcing this act and are considering programs to require farmers in critical coastal areas to implement recommended management measures or meet certain erosion or pollution reduction criteria (Magleby, Crosswhite, Crutchfield, Dickason, Osborn, and Sandretto, 1991).

State-Funded Programs

Most States provide some funding to conservation districts in support of USDA/NRCS technical assistance staff. In fiscal 1994, that funding amounted to just over $500 million (Magleby and Sandretto, 1994). In addition, 30 States provide financial or regulatory incentives for installing and maintaining best management practices to promote soil conservation and to protect surface water quality (table 5). Financial incentives include cost-sharing programs (in 25 States); income or property tax credits or deductions (in 7 States); no- or low-interest loans (in 5 States); and purchasing conservation easements or development rights on agricultural lands (in 2 States). Most State laws that provide financial assistance to private landowners follow the Federal model of financial assistance by providing cost sharing for the installation of approved types of conservation practices under contracts with conservation districts. State income tax incentives are less common but also follow Federal law in allowing landowners to take charitable deductions for gifts of conservation restrictions and easements to approved organizations (Holmes, 1987).

On the regulatory side, 19 States require either approved plans or permits for "land-disturbing" activities that could cause accelerated soil erosion or sediment and pollutant discharges into waterways or could violate

Table 5—State incentive programs for erosion control by type of incentive provided, early 1990's

State	Type of incentive				
	Regulations and penalties	Cost share	Low-interest loans	Tax credits	Purchase of easements
Alabama		X			
Arkansas				X	
Colorado	AC	X			
Delaware	AC[1]	X			
Florida	DA	X			
Idaho	DA, IC	X	X		
Illinois	IC, ES	X			
Indiana		X			
Iowa	IC, ES	X	X	X	
Kansas	ES	X			
Maine	AC[1]	X			
Maryland	IC	X			
Michigan	AC				
Minnesota	AC[1], DA, ES	X			X
Mississippi		X			
Missouri		X	X		
Montana	AC	X	X		
Nebraska		X			
New Jersey		X			X
North Carolina		X		X	
Ohio	AC, IC, ES	X			
Oklahoma	DA, IC	X			
Oregon				X	
Pennsylvania	IC	X			
South Carolina	AC			X	
South Dakota	DA, IC, ES	X			
Utah			X	X	
Virginia		X			
Wisconsin	IC, ES	X		X	
Wyoming	IC, ES	X			
Total 30 States[2]	19	25	5	7	2

AC = All cropland; DA = Designated areas only; IC = If complaint; ES = If exceed soil loss limits.
[1]Applies only if State or Federal cost sharing is available. [2]States not listed had no special incentive program for soil erosion control.
Sources: Ribaudo and Woo (1991). Massey (1989). National Association of Conservation Districts, Washington, DC (1988). U.S. Environmental Protection Agency (1984).

compliance with established permissible soil-loss limits (table 5). Users of agricultural and forest land must implement a farm conservation plan or meet district conservation standards for the relevant type of operation. Conservation standards are performance standards which may include soil loss limits, erosion control practices, and water management practices. Most of the 19 States provide farmers cost-sharing assistance to help them meet the requirements.

Policy Formulation and Implementation Process

The formulation and implementation of conservation policies and programs in the United States can be a lengthy process involving extensive public participation in efforts to resolve conflicting views and interests.

Policy Formulation

The policy formulation process involves the Executive Branch and the Congress, usually with considerable interaction within and among agencies, congressional committees for agriculture and the environment, affected businesses, and public interest groups (fig. 6). Consensus or compromise policies and program guidelines become embodied in legislation passed by Congress and signed by the President. Actual implementation of authorized policies and programs depends on funding derived from a separate appropriations act which goes through a similar process of interaction to obtain consensus.

The authorization and appropriations stages together often take months or years, and authorized programs sometimes wither and die from lack of appropriations. In some cases, annual appropriations legislation adds restrictive provisions, such as those for ACP that specify cost-sharing assistance is not to be used for practices that primarily increase production and that achieve little resource conservation or pollution abatement.

Policy Implementation

Once an act is authorized and funded, the administrative agencies, usually in consultation with other agencies and interest groups, develop proposed program rules and regulations that go through informal and formal public reviews before being made final.

Many conservation programs to be implemented at the State and local levels require States to submit plans or project proposals and funding needs for Federal approval before actual funds are transferred. For multiyear projects, annual plans of work and documentation of progress are required to receive continued funding.

Federal laws regulating the use of natural resources sometimes require that the responsible Federal agency delegate regulatory responsibilities to State agencies when State programs meet Federal standards, and provide the responsible State agencies with various types of technical and financial assistance.

National Conservation Program Delivery

A generalized model of a State/local soil conservation structure includes a State conservation organization to bring together the relevant Federal and State agencies with a soil conservation mission, a system of special-purpose local (county) conservation districts that are authorized by State law to provide technical assistance to farmers, and county Agricultural Stabilization and Conservation (ASC) committees to handle cost sharing (Libby, 1982). This system assures that financial support and technical assistance are focused on a common set of problems.

USDA has a memorandum of understanding with each conservation district to assist in carrying out a long-term conservation program. Conservation districts have proven to be practical organizations through which local farmers and the Federal Government can join forces to carry out needed soil conservation practices (Rasmussen, 1982). NRCS provides technical assistance to farmers and other land users, including local, State, and Federal agencies that manage publicly owned land, and helps them and district supervisors to draw up and implement conservation plans.

Providing Federal cost-sharing assistance to farmers and ranchers for voluntary installation of approved conservation practices is the responsibility of State and county ASC committees. Through the Agricultural Conservation Program (ACP), funds are allocated among the States through State ASC committees on the basis of soil and water conservation needs. ACP practices eligible for cost sharing are established by a national review group representing all USDA agencies with conservation program responsibilities, the Environmental Protection Agency, and the Office of Management and Budget. The practices are designed to help prevent soil erosion and water pollution from animal wastes or other nonpoint sources, to protect the productive capacity of farmland and rangeland, to conserve water, to preserve and develop wildlife habitat, and to conserve energy (Holmes, 1987).

The Secretary of Agriculture can also designate critical resource problem areas for cost sharing and technical assistance targeting based on the severity of the problem and the likelihood of achieving improvement.

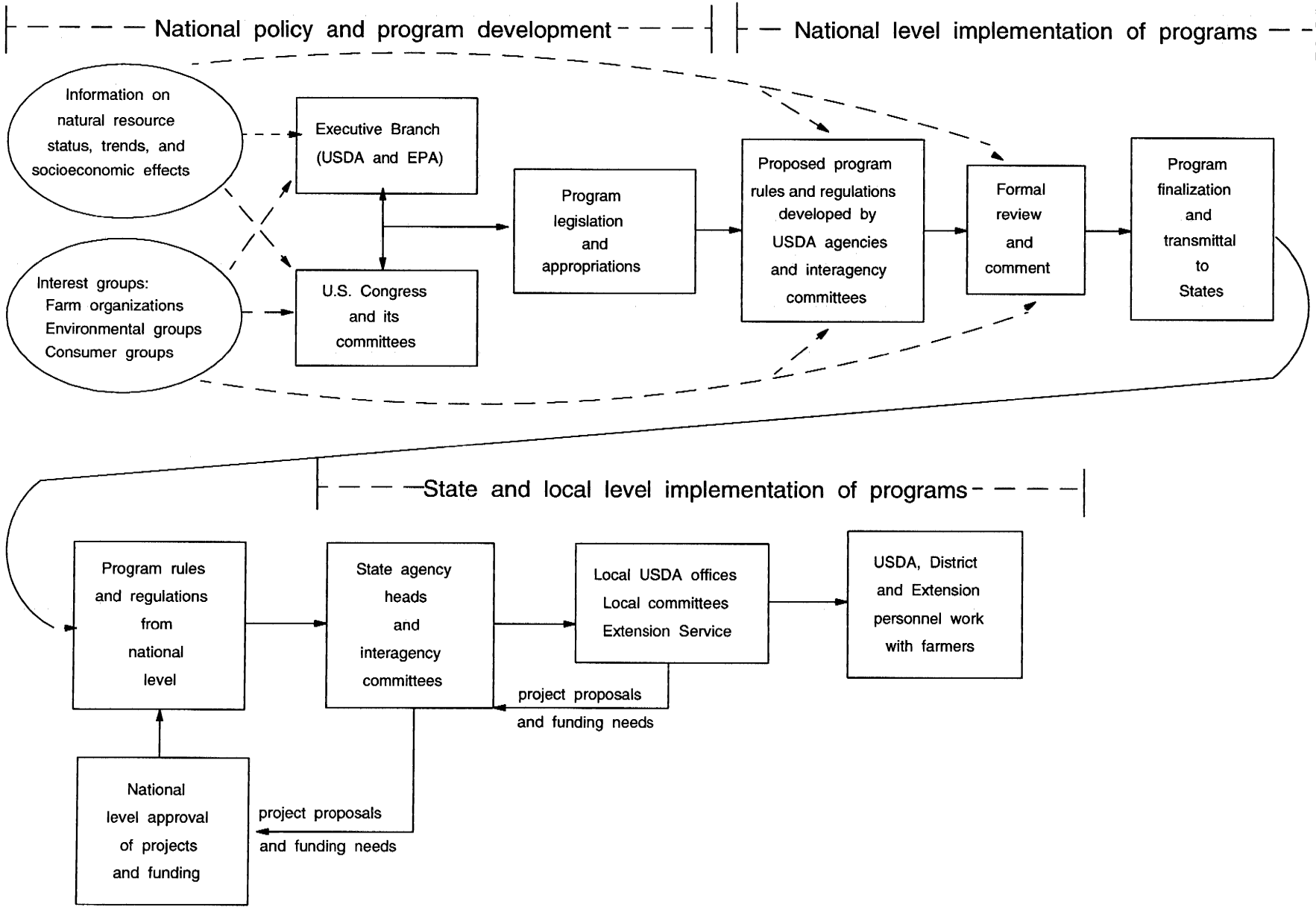
Erosion's Economic and Environmental Effects

Considerable governmental effort goes into the collection and assessment of data on economic and environmental effects of erosion and associated runoff from agricultural lands. Substantial attention is also devoted to other conservation and environmental research and on finding ways to reduce adverse impacts of erosion. In 1994, USDA directed an estimated $277 million to conservation data collection and research (table 4).

Data Collection and Assessments

This section summarizes the major activities of data collection and assessment that provide information for estimating the environmental and economic effects of

Figure 6
U.S. conservation policy and program development and implementation



erosion and related conservation efforts in the United States.

Soils Classification and Mapping

The systematic and scientific classification and mapping of U.S. soils began in 1899. Various guidance and instruction books were issued over the years as experience was gained and methods were improved. During the 1930's, aerial photography began facilitating U.S. soil-mapping efforts. The expanding Federal conservation programs provided a further practical use for the soil classifications and maps (Simonson, 1987).

In 1965, the Soil Conservation Service (SCS) began implementing a new, more flexible taxonomy of soils which permitted classification of soils according to changeable sets of criteria, such as susceptibility to the downward leaching or horizontal flow of pollutants. About 80-90 percent of U.S. land and 75 percent of U.S. counties have now been classified and mapped according to this new system. Most acreage with farm program crops or containing highly erodible lands according to the definitions set out in the mapping system have been mapped to support implementation of USDA commodity and conservation programs.

National Resources Inventories

Every 5 years since 1977, the Natural Resources Conservation Service (old SCS) has conducted a statistically representative National Resources Inventory (NRI) of land cover and use, soil erosion, prime farmland, and other natural resource statistics on non-Federal, rural land. Based on actual field observations by NRCS technicians, the NRI provides a record of the Nation's conservation accomplishments and future program needs and is the key data source for deciding policy and developing conservation programs. Earlier inventories, called the Conservation Needs Inventory (CNI), were conducted in 1958 and 1967.

Soil and Water Resources Conservation Act Appraisals

In 1977, Congress directed the Secretary of Agriculture to (1) continuously appraise the soil, water, and related resources on non-Federal land; (2) develop a program for furthering conservation, protection, and enhancement of these resources; (3) make a report to Congress and the public; (4) provide annual evaluation reports. The first of these mandated appraisals was published in 1981 (USDA, 1981) and the second in 1989 (USDA, SCS, 1989c). The third is scheduled for 1997. The appraisals are based on the National Resources Inventories; studies performed by USDA, other Federal agencies, and contractors; and projections of future changes derived from extensive modeling efforts.

USDA and State Research

In addition to the inventories and appraisals outlined above, USDA has continuous research programs underway on soil erosion and related resource issues and problems (see box—"USDA Conservation Programs Prior to 1985"). Of the $277 million expended in 1994 for conservation-related research by six USDA agencies (table 4), about four-fifths supported research by USDA personnel, while the remainder went to State universities and experiment stations for cooperative research. Adding to the latter were funds appropriated for soil- and water-related research by the States themselves, probably several times the funds coming from USDA.

Model Predictions

Mathematical models of physical processes are now used by USDA and university researchers to predict the physical effects of weather and human activities on soil and water. The Universal Soil Loss Equation (USLE) and the Wind Erosion Equation have been used for many years and are the basis for erosion estimates in the NRI's and for field-level conservation planning. Both equations estimate gross erosion as a function of the soil's characteristics, climate factors, current crop and tillage system, and any supporting conservation practices. Both are in the process of revision and improvement.

The model most frequently used to predict yield and onsite effects of erosion is the Erosion Productivity Impact Calculator (EPIC) (Williams, Renard, and Dyke, 1983; Williams, Putman, and Dyke, 1985). EPIC is a daily plant-growth model that considers characteristics of the soil, field operations and inputs, the needs of the crop being grown, and daily rainfall and temperature. Based on these data, the model predicts crop yield, soil erosion, water and chemical infiltration, and edge-of-field runoff. For recent RCA appraisals, EPIC has been run for a sufficient number of representative soils and conditions to permit extrapolations and aggregations to major land resource areas as well as to the Nation as a whole.

Another field-scale model in common use is Chemicals, Runoff, and Erosion from Agricultural Management Systems (CREAMS), which estimates some water quality parameters as well as erosion (USDA, SEA, 1980). A model commonly used for estimating project-wide or watershed-wide sediment and chemical runoff is Agricultural Non-Point Source (AGNPS), which adds a routing component to CREAMS (Young,

Onstad, Bosch, and Anderson, 1987). AGNPS can estimate the movement of pollutants through the watershed and into a discharge outlet or a body of water.

Significance of Onsite and Offsite Physical and Economic Effects

Until the 1980's, onsite effects of erosion on soil productivity were the primary concern. More recently, increased awareness of the environmental effects of soil losses has shifted emphasis toward reducing offsite damages, which may be considerably greater than the onsite effects.

Onsite Damages From Erosion

The major onsite effect of soil erosion is reduced productivity. When soils erode, nutrients are carried away, plant root development is restricted, water-holding capacity generally declines, and productivity is impaired. Even though yields may be maintained or even increased in the short run by using improved seed and applying additional fertilizer, yields over time will be lower than would otherwise be the case. Productivity losses from erosion take longer to be realized with deeper topsoil and may not be clearly discernible within a particular producer's timeframe.

Using the EPIC model, estimates have been made of the yield effects of erosion continuing at 1982 levels for 100 years, assuming no change in technology. On a national basis, corn, cotton, and soybean yields were predicted to be 3-4 percent lower than they would otherwise be, and wheat yields 1-2 percent lower (Strohbehn and Alt, 1987). Such yield losses, combined with the fertilizer and lime increases, would translate into an annual loss of just over $3 billion (1982 dollars) by the 100th year (Alt, Osborn, and Colacicco, 1989).

In the United States, significant productivity losses to erosion appear limited to a small acreage of vulnerable soils. While about 43 percent of total cropland in 1982 was eroding over the tolerable (T) level (the rate of erosion above which long-term productivity of the soil diminishes) (table 3), only about 18 million acres or 20 percent of total cropland would suffer productivity losses of 2 percent or greater if the current rate of erosion continued over 100 years (Strohbehn and Alt, 1987). These 18 million acres require (and under the Food Security Act of 1985 are now getting) special action to preserve productivity and reduce offsite damages.

Although erosion-caused productivity losses do not currently pose a threat to the Nation's food and fiber supply, such losses could hurt the agricultural economies of particular areas. Hence, productivity losses remain a concern.

Offsite Damages From Erosion

Various types of offsite damage result from water-based erosion in the United States. Ribaudo (1989), using his most likely estimate of annual damages, shows recreation as the major loser, followed by municipal and industrial water use and by increased costs of water storage (table 6). Together the various types of offsite damage from water-based erosion total $5-$17 billion (1986 dollars) annually.

Estimates of offsite damage caused by dust from wind erosion exist only for the drier western areas of the United States, where it is a significant problem, and those estimates are, at best, very rough. Dust increases cleaning and maintenance costs, damages machinery, and adversely affects health. In the Southern Plains, Mountain States, and Northern Plains, offsite damages from wind erosion could exceed those from water erosion. Overall for 17 Western States (including the Great Plains), Piper and Lee (1989) estimated offsite damages from wind erosion to be $4-$12 billion per year under early 1980's conditions.

Table 6—Annual offsite damage from soil erosion, by damage category

Damage category	Offsite damage	
	Best estimate[1]	Range
	Million 1987 dollars	
Freshwater recreation	2,080	826-6,559
Marine recreation	599	439-2,399
Water storage	1,090	654-1,524
Navigation	749	533-933
Flooding	978	653-1,546
Roadside ditches	535	268-804
Irrigation ditches	118	59-159
Freshwater commercial fishing	60	53-83
Marine commercial fishing	390	383-530
Municipal water treatment	964	496-1,432
Municipal and industrial use	1,196	665-1,599
Steam power cooling	24	21-34
Total	8,783	5,050-17,602

[1]Best estimate is the most likely extent of offsite damage.
Source: Ribaudo, 1989.

Benefits From Soil Conservation

Estimated reductions in soil erosion resulting from the current conservation programs are as follows:

	Million tons reduced/ year
Annual acreage reduction programs (Magleby and others, 1990)	60-120
Agricultural Conservation Program (same)	25-40
Conservation Technical Assistance only (same)	60-70
Subtotal	145-230
CRP when fully implemented (Ribaudo, 1989)	685-776
Conservation compliance by 1995 (Magleby and Sandretto, 1994)	450-750
Subtotal Food Security Act of 1985 (CRP and compliance)	1,135-1,526
Total potential of above programs	1,280-1,756

The 1985 act's programs targeted to highly erodible and other environmentally sensitive lands have already surpassed the annual soil savings of the older USDA programs. Erosion reductions achieved from lands already in the CRP are estimated to exceed 690 million tons annually, a drop of one-fifth in cropland erosion from the mid-1980's. When expected soil erosion reductions from conservation compliance are added, even if less than full participation is achieved, total erosion reduction from all programs could exceed 1 billion tons. These savings would represent over a one-third reduction in cropland erosion from the levels of the mid-1980's and over a one-fourth reduction in total erosion on rural non-Federal lands.

What are the potential economic benefits resulting from these soil erosion reductions? Some estimates have been made (present value of the benefits over the duration of the reduction, assuming a 4-percent discount rate):

	Productivity benefits	Water quality	Dust reduction
		Million dollars	
ACP, CTA, and GPCP programs in 1983 (1983$) (Strohbehn, 1986)[1]	99	201-508	NA
CRP by year 2000 (1986$)[2] (Ribaudo, 1990)	800-2,400	1,970-5,507	400-1,000
Compliance on 63 million acres (1993$) (Canning, 1994)[3]	325	21,750	3,050

The CRP, in addition to benefits related to reduced soil erosion, also takes land out of production, expands wildlife habitat, reduces commodity surpluses and USDA commodity program costs, and provides participating farmers with a dependable source of income for 10 years. However, the program also increases some prices consumers have to pay and requires additional expenditures by farmers and government to establish vegetative cover. Young and Osborn (1990) have estimated the national net economic benefits of a 45-million-acre CRP at $3-$11 billion in 1986 dollars. The CRP could also generate some ground water benefits from reduced use of fertilizers and other chemicals in the Southern Plains, Mountain, and Appalachian regions, and particular areas of other regions (Ribaudo, 1989). The estimates of benefits and costs of the CRP have been revised to reflect changes in the program, but the general magnitudes and net benefits remain similar (Osborn and Konyar, 1990).

The CRP has taken out of production 20 to 25 percent of the cropland in a number of counties across the country, raising concerns about how local economies might be affected. Hines, Sommer, and Petrulis (1991) evaluated 10 such areas using the IMPLAN input-output model. Except for some selected businesses, such as input suppliers, the results indicated that the CRP would not severely affect economic activity in any of the areas. CRP payments would largely offset reduced agricultural activity. Reductions in economic activity ranged from less than 1 percent up to 5.7 percent, with 7 of the 10 areas having less than a 3-percent drop.

The main policy concern with conservation compliance has been the extent to which farmers with highly erodible land (HEL) will choose to implement the practices in the conservation plans. Farmers may gain from compliance if they can do so by using some form of residue man-

[1]Based only on practices installed in 1983 under the Agricultural Conservation Program (ACP), the Conservation Technical Assistance (CTA) Program, and the Great Plains Conservation Program (GPCP). Assumes benefits continue in perpetuity. Benefits will be less if practices are not maintained.

[2]Assumed a 45-million-acre CRP, with all lands back into production by the year 2000. Benefits of the current 36.4 million acre CRP will be lower if all lands go back into production, but could be higher if some lands remain out of production beyond the year 2000.

[3]Assumes Canning's annual per acre benefit estimates continue into perpetuity and that compliance affects 63 million acres net (149 million acres of designated highly erodible lands less 15 percent estimated noncompliance (23 million acres), less those in the CRP (28 million acres) and those already eroding below the tolerance level without further treatment (35 million acres)). Benefits will be higher to the extent CRP lands go back into production and farmers implement conservation compliance plans on the lands in order to be eligible for USDA program payments.

agement, such as conservation tillage, which reduces costs, albeit by requiring some initial investment and more management. If farmers must also install terraces or change to contour farming or alter cropping patterns, they will likely weigh the associated costs against the advantages of remaining eligible for USDA program benefits. On the cost side, Barbarika and Dicks (1988) estimated that reducing erosion to the T level on all HEL cropland would annually cost the Nation's farmers $700 billion. However, to reduce the cost and increase participation, conservation compliance now allows farmers to implement alternative conservation systems that do not require reducing erosion to the T level.

Canning (1994) estimates that if 85 percent of the HEL-designated lands come into compliance, the water quality, air quality, and productivity benefits will together exceed the producer and government implementation costs in most regions. The potential water and air quality benefits of compliance will be substantial if most farmers of highly erodible lands implement and maintain practices in the conservation plans.

Implications of Severe Natural Events

Economic implications of severe natural events vary in the loss value and the duration of the economic effects. Short-duration natural phenomena, such as floods, landslides, earthquakes, volcanic eruptions, and wind storms, wreak high losses in life and economic value in very short periods of time. However, the effects may not be as prolonged as they first appear. For example, the calamitous effects of the eruption of Mount St. Helens in the early 1980's are fading rapidly as the readily renewable resource of timber is regenerating its economic and scenic value while stabilizing the soil. Recovery from a prolonged drought, such as that of 1986-92 in some parts of the West, may take longer, and the associated losses in soil erosion and productivity may accumulate to many times the cost of most short-duration natural disasters.

The Emergency Conservation Program, begun in 1978, provides financial help to farmers for rehabilitating cropland damaged by natural disasters. USDA programs also have the flexibility to handle extreme situations. During the 1986-92 drought, USDA analysts used the EPIC model to predict crop yields under different weather scenarios as the drought progressed and to provide policymakers with a basis for altering programs. Haying and grazing restrictions on CRP lands and annual set-aside acreage were relaxed to provide farmers a source of livestock feed. In cases where the drought affected the establishment of protective cover on CRP lands, USDA provided a second or third year of cost sharing.

USDA programs help overcome immediate damages from flood, fire, landslide, or other events that prevent a watershed from safely accommodating water flow. However, the principal focus of USDA conservation programs is on preventing or mitigating potential losses. Increased emphasis is being placed on disaster prevention, such as gathering more and better soil-moisture information to predict droughts and to more successfully ameliorate their effects. USDA supports mitigation by monitoring natural resources and encourages and assists in developing land use plans that avoid risk from natural disasters. USDA also participates in an interagency Federal Subcommittee for Natural Disaster Reduction to develop strategy and implementation plans to reduce the effects of natural disasters.

The potential effect of climate change has been placed on the agenda of research agencies. USDA's Agricultural Research Service has begun a major project to study the effect of increases in ultraviolet light on plant and crop systems. A new laboratory, "TERRA," is being formed by several agencies to address regional and global effects of climate change on land and terrestrial systems. The Environmental Protection Agency has begun an Environmental Monitoring and Assessment Program to collect baseline data to help measure the effects of such change. The Forest Service conducts a major research program on the effects of tropical deforestation on climate change. The Economic Research Service is assessing the potential economic effects of climate change. The NRCS is beginning to assess the potential for crops, cover, and soil to sequester carbon.

Conservation Policy and Program Performance

Responsibility for farming practices on U.S. farms rests ultimately with farm owners and operators. Since the 1930's, many farmers have voluntarily implemented conservation and water quality practices, often with technical and financial assistance provided by Federal and State programs, but many others have not. This report concludes by reviewing the performance of U.S. conservation policies and programs, the key factors affecting this performance, and some options for improving performance and effectiveness.

Performance of Current Policies and Programs

Physical measures of performance of soil conservation policies and programs include reductions in the amount of soil erosion, declines in the acreage with critical erosion problems, and increases in land treated with conservation practices.

Reductions in Erosion

U.S. conservation programs have reduced erosion on both a total and a per acre basis. As a result of conservation activities, erosion in the 1980's was less than during the 1930's despite the effects of more land in production and a larger proportion of land in row crops (table 3). Even so, by the mid-1980's, agriculture was identified as the remaining major source of sediment and other nonpoint source pollutants affecting the Nation's surface waters. This finding spurred environmental groups and the general public to call for new measures to substantially reduce erosion and discharges of sediment. In response, Congress included provisions in the 1985 and 1990 farm legislation for special programs for soil conservation, wetland protection, and environmental quality.

These new programs are reducing erosion. Between 1987 and 1992, cropland erosion dropped 670 million tons, or by one-fourth (table 3). This was double the drop during 1982-87. By the end of 1993, the CRP had reduced erosion by 690 million tons, and conservation compliance had reduced it by an estimated 450 million tons (Magleby and Sandretto, 1994). The future of the CRP beyond 1995 is uncertain, but even if the lands go back into production, they will be subject to compliance requirements if the farmers want to maintain eligibility for certain USDA program benefits, and those benefits continue to exist. By 1995, CRP and Conservation Compliance together could achieve a one-third reduction in soil erosion from the mid-1980 levels.

In early CRP signups, most of the soil-erosion reduction came from wind erosion, primarily in the West. By contrast, as a result of subsequent program changes, 70 percent of the erosion reduction on land enrolled since 1990 has occurred in sheet and rill (water-caused) erosion that occurs primarily in the East. While both forms of erosion can reduce agricultural productivity, reduction of sheet and rill erosion often produces greater offsite water quality benefits.

Declines in Acreage With Critical Problems

Lands with critical erosion problems include those eroding substantially above the tolerance or T value and those contributing large amounts of sediment and other pollutants to priority surface waters (often the same lands, but not necessarily so). Studies in the late 1970's and early 1980's criticized existing conservation programs for lack of targeting, documenting that large proportions of Federal technical assistance and cost-sharing funds were often used on slight-to-moderate erosion problems, which sometimes left relatively few resources for long-term conservation treatment of highly erodible land (U.S. GAO, 1986; USDA/SEA, 1980; Strohbehn, 1986).

During the 1980's and early 1990's, progress was made toward targeting of conservation programs to lands with critical erosion problems. This progress included special targeted projects in the Rural Clean Water Program, ACP water quality projects, the CRP, the compliance provision, and most recently, projects in USDA's Water Quality Initiative (now called Water Quality Program). Also some progress in targeting came from agency programs for setting priorities and training field personnel. The NRI statistics confirm progress. Between 1982 and 1987, cropland acres eroding above 2T, mostly highly erodible lands, dropped by over 6 million, and between 1987 and 1992, by over 11 million (table 7).

Table 7—Cropland erodibility, contiguous United States, 1982-92

Item	1982[1]	1987[1]	1992	Change 1982-87	Change 1987-92
			Million acres		
Cropland area					
Highly erodible[2]	125.1	117.3	105.5	-7.8	-11.8
Less erodible	295.9	289.3	276.8	-6.6	-12.5
Total	421.0	406.6	382.3	-14.4	-24.3
Cropland erosion relative to tolerance (T)[3]					
Eroding at T or below	318.9	315.1	309.5	-3.8	-5.6
Eroding above T to 2T	53.8	49.4	42.0	-4.4	-7.4
Eroding above 2T	48.3	42.1	30.8	-6.2	-11.3
Total	421.0	406.6	382.3	-14.4	-24.3

[1]Revised estimates published in 1994. [2]Erodibility index is 8 or greater. [3]The tolerance level is the rate of erosion above which productivity can diminish.

Source: USDA, Soil Conservation Service, 1994.

The new conservation programs or provisions—CRP, compliance, and sodbuster—are explicitly targeted to highly erodible lands. The CRP has placed 36.4 million acres of highly erodible or environmentally sensitive cropland in a 10- to 15-year conservation reserve (Osborn, 1994). As a result of rule changes, higher proportions of recently accepted land came from conservation priority watersheds, such as the Chesapeake Bay, Long Island Sound, and the Great Lakes region.

The conservation compliance program for reducing erosion on highly erodible lands has also made progress. Over 149 million acres are included in farm conservation plans developed by SCS as required by law. On over 80 percent of these acres, the plan was probably fully implemented by the January 1995 deadline to avoid the loss of certain USDA program benefits. Compliance requirements will also apply to highly erodible lands coming out of the CRP after completion of the 10- to 15-year reserve.

The sodbuster provision has probably deterred some farmers from converting highly erodible land to cultivated cropland (Soil and Water Conservation Society, 1991). Also, farmers who have converted such lands and implemented conservation plans to retain USDA benefits have reduced erosion to T or nearly T levels in most cases. Over 1,900 farmers had been found in violation of sodbuster and compliance requirements through 1992, and declared ineligible for USDA programs, losing over $7.3 million in benefits (Canning, 1994). Spot checks are made for sodbuster violations, and a 1991 study found 65 percent of sample farms had potential violations (Soil and Water Conservation Society, 1991).

T-Level Control Questioned

Reducing erosion to or below the T or tolerance level so as to maintain the long-term productivity of the soil over time has been the working goal of NRCS in its farm conservation planning since the earliest days. But, now that the offsite effects of erosion appear to substantially exceed the productivity effects and public demands for water quality have risen, the goal of reducing erosion to T or less is being questioned. From a water quality standpoint, the T goal is often not cost-effective, since more erosion reduction can be achieved in a watershed for a given expenditure using lower cost management practices on a wider basis than by putting in the more costly structural measures often needed to achieve the T goal (Magleby, Piper, and Young, 1989). Also, farmers often see achievement of T as impractical from an economic perspective unless the required measures are highly subsidized by government cost sharing. NRCS has been preparing alternative conservation plans for many highly erodible lands, plans that will achieve something less than erosion reduction to the T level, in order to reduce farmers' costs and increase willingness to implement additional conservation.

Increases in the Use of Conservation Practices

Rotation between row crops and close-grown crops or between crops and fallow or hay occurs on much U.S. cropland and has soil-conserving effects. In 1993, about one-third of the cropland in corn, soybeans, cotton, and wheat was in some kind of soil-conserving rotation (Padgitt and Bull, 1994). In addition, a sizable acreage of cropland and all CRP lands have other soil conservation practices in place (table 8). The most common other practice in 1992 was conservation tillage, 87-89 million acres, and other forms of crop residue management.[4] Also frequently applied were pasture and hayland management, terraces, irrigation water management, contour farming, and grassed waterways. Conservation practices increasing the most in use between 1982 and 1992 were pasture and hayland management and conservation tillage on cropland, and grass cover on lands placed in the CRP.

High-residue forms of conservation tillage, no-till and ridge till, are increasing in use and accounted for about 15 percent (39 million acres) of the 284 million acres planted to crops in 1994 (table 9).[5] High-residue tillage systems leave as much as 70 percent of the soil surface covered with crop residues and offer more wind and water erosion protection than other till-

[4]Such management usually includes a reduction in the number and intensity of tillage operations, including the elimination of plowing (inversion of the surface layer of soil with a moldboard or disk plow) and/or a reduction in the number of passes over the field with other tillage implements (disk, field cultivator, chisel, harrow, or the like) so as to leave sufficient residue cover on the soil surface as protection against soil erosion. Crop residue management includes all field operations that affect residue amounts, orientation, and distribution throughout the period requiring protection. Conservation tillage is defined as any tillage and planting system that maintains at least 30 percent of the soil surface covered by residue after planting to reduce soil erosion by water, or where soil erosion by wind is the primary concern, maintains at least 1,000 pounds per acre of flat, small grain residue equivalent on the surface during the critical soil erosion period.

[5]In no-till, the soil is left undisturbed from harvest to planting except for nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaners, disk openers, in-row chisels or roto-tillers. Weed control is accomplished with herbicides and/or cultivation. In ridge-till, the soil is left undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between ridges. Weed control is accomplished with herbicides and/or cultivation. Ridges are rebuilt during cultivation.

Table 8—Applied soil conservation practices on U.S. cropland and Conservation Reserve Program (CRP) lands, 1982 and 1992

Land use and conservation practice	1982[1]	1992	Change,1982-92
		Million acres	
Cropland excluding CRP[2]	421.0	382.3	-38.7
Conservation tillage	68.0[3]	86.9	18.9
Contour farming	34.1	31.2	-2.9
Field windbreaks	6.0	6.1	0.1
Grassed waterways or outlets	19.3	24.7	5.4
Irrigation water management	28.5	31.5	3.0
Pasture and hayland management	22.3	65.5	43.2
Stripcropping and contouring	3.5	3.5	0.0
Terraces	28.4	34.3	5.9
CRP lands[2]	0.0	34.0	34.0
Grass cover	0.0	30.9	30.9
Tree cover	0.0	2.3	2.3
Wildlife habitat cover	0.0	2.0	2.0

[1]Some additional acres may have been treated or served by the practice. The Inventory only obtained acreage for three practices per site and some sites may have had more than three applied conservation practices. [2]Individual practices sum to more than total acres in each land use because of lands with more than one practice. [3]Revised estimate by Schertz (1988) based on the same definition of conservation tillage as used in 1992. See table 9, footnote 1 for the definition.

Sources: USDA, Soil Conservation Service, National Resources Inventory, 1982 and 1992. Osborn, 1993.

age systems. These and other conservation tillage systems are frequently used with double cropping, including over 66 percent of the double-cropped soybeans, 53 percent of the double-cropped corn, and 50 percent of the double-cropped sorghum acreage.

ACP cost-shared practices were applied to around 9 million acres per year during the 1980's. Starting in 1986, the CRP shared the cost for establishing permanent cover on lands going into this program, substantially increasing total cost-shared acreage to over 20 million acres in 1987. In 1993, with few new lands going into the CRP, acres treated or served by cost-shared soil conservation practices dropped to under 8 million.

Factors Affecting Farmers' Adoption of Conservation

Numerous factors influence adoption of soil conservation by U.S. farmers and thus the performance of soil conservation policies and programs. Three major factors are the failure of farmers to perceive an erosion problem on their own land; market forces and economic factors; and the distortions caused by commodity program rules and incentives.

Failure of Farmers To Perceive a Problem on Their Own Land

Farmers often fail to use conservation practices and systems because they do not perceive a problem on their own land, although they may perceive that soil erosion problems exist in their counties and communities (Nowak, 1991). The General Accounting Office (1986) estimates that the most influential factor in the conservation decision of farmers is their perception of the level of erosion on their own land. Farmers who understand the magnitude of their land's erosion are more likely to use conservation practices. However, rising yields associated with increases in fertilizer and pesticide use have made it more difficult for farmers to identify the harmful effects of erosion on soil productivity.

Market Forces and Economic Factors

In making conservation investment decisions, producers consider market forces, interest rates, and the profitability of practices (Nielsen, Miranowski, and Morehart, 1989). Farmers and ranchers are less likely to use conservation practices if such practices are relatively expensive, or if the practices significantly reduce profits or increase risk. However, even when conservation practices are profitable in the long run, some operators may not adopt and practice conservation because of shortrun considerations such as high initial costs of implementation (new equipment requirements) and short-term leases on land being operated.

Table 9—National use of various tillage systems, 1989-94[1]

Item	1989	1990	1991	1992	1993	1994
			Million acres			
Total area planted	279.6	280.9	281.2	282.9	278.1	283.9
Area planted with:						
No-till	14.1	16.9	20.6	28.1	34.8	39.0
Ridge-till	2.7	3.0	3.2	3.4	3.5	3.6
Mulch-till	54.9	53.3	55.3	57.3	58.9	56.8
Total conservation tillage	71.7	73.2	79.1	88.7	97.1	99.3
Other tillage types:						
15-30 percent residue	70.6	71.0	72.3	73.4	73.2	73.1
Less than 15 percent residue	137.3	136.7	129.8	120.8	107.9	111.4
Total other tillage types	207.9	207.7	202.1	194.2	181.0	184.6
			Percent			
Percentage of area with:						
No-till	5.1	6.0	7.3	9.9	12.5	13.7
Ridge-till	1.0	1.1	1.1	1.2	1.2	1.3
Mulch-till	19.6	19.0	19.7	20.2	21.2	20.0
Total conservation tillage	25.6	26.1	28.1	31.4	34.9	35.0
Other tillage types:						
15-30 percent residue	25.3	25.3	25.7	25.9	26.3	25.8
Less than 15 percent residue	49.1	48.7	46.1	42.7	38.8	39.3
Total other tillage types	74.4	73.9	71.9	68.6	65.1	65.0

[1]Tillage system definitions:

Conservation tillage—Any tillage and planting system that maintains at least 30 percent of the soil surface covered by residue after planting to reduce soil erosion by water; or where soil erosion by wind is the primary concern, maintains at least 1,000 pounds (per acre) of flat, small grain residue equilvalent on the surface during the critical wind erosion period. Includes mulch till, ridge till, and no-till.

Mulch till—The soil is disturbed prior to planting. Tillage tools such as chisels, field cultivators, disks, sweeps or blades are used. Includes any tillage system that leaves 30 percent or more residue after planting that is not a no-till or ridge till system.

Ridge till—The soil is left undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between ridges.

No-till—The soil is left undisturbed from harvest to planting except for nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaners, disk openers, inrow chisels, or roto-tillers.

15-30 percent residue—Tillage types that leave 15-30 percent residue cover after planting, or 500-1,000 pounds per acre of small grain residue equivalent throughout the critical wind erosion period.

Less than 15 percent residue—Tillage types that leave less than 15 percent residue cover after planting, or less than 500 pounds per acre of small grain residue equivalent through the critical wind erosion period.

Source: Conservation Technology Information Center, National Crop Residue Management Surveys, West Lafayette, IN.

Distortions Caused by Commodity Program Rules and Incentives

Price and income support programs influence crop production and management decisions through their effects on the relative prices of program and nonprogram crops and the relative production risks of these crops. These incentives may encourage the production of program crops more erosive than nonprogram crops and the cultivation of marginal lands more subject to soil erosion and moisture deficiencies. Farm program incentives also reduce price and production risks through insured prices and insurance programs that encourage production in more risky locations and conditions.

High and stable prices for program crops encourage use of fertilizers and pesticides and the adoption of new yield-increasing technology. Increased yields on program crops have contributed to stock build-ups.

Several legislative changes have been made since 1985 to help offset the distortions. Violators of conservation provisions can now lose a whole host of farm program benefits, including deficiency and conservation program payments. Congress also provided greater base flexibility for program crops, further lessening the role that commodity programs play in planting decisions.

Options for Improving the Performance of Conservation Programs

Conservation policies and programs in the United States have changed, especially in recent years, to address a wider public interest in natural resources and environmental quality. Additional changes are being considered to further improve performance and effectiveness. This section addresses some options for improving the performance of conservation programs.

Targeting and Expanding Traditional Assistance

Traditional technical, financial, and education and extension assistance programs have improved in more specific targeting of efforts to areas with onsite and offsite problems. However, in many locations these programs are still available on a first-come, first-served basis. Options for further targeting of these programs include the following:

Direct programs to priority areas identified in section 319 assessments and coastal zone and regional programs. The Water Quality Initiative has moved in this direction, but many more priority areas exist that could be targeted.

Increase assistance for highly erodible lands. NRCS has directed considerable technical assistance toward developing conservation compliance plans on these lands, but greater financial, technical, and extension assistance could also be targeted to furthering the implementation of the plans.

Expand microtargeting. Even within identified priority areas, some lands or activities are more critical than others in achieving environmental objectives. More critical areas and activities could be treated first or be provided higher levels of technical and financial assistance as incentives for accelerating improved practice adoption by farmers. In the CRP for example, HEL and environmentally sensitive lands which promised superior benefit/cost ratios would be accepted first.

Greater targeting faces some challenges. Effective targeting (deciding where additional assistance efforts should go) requires greater information, not only on the physical aspects of the problem, but also on the public costs and on the value of the probable environmental improvements. More concurrence and coordination must be achieved among agencies providing assistance. More management and monitoring is necessary to assure that the targeting is effective. Political opposition to targeting is sometimes a problem, particularly if funds and personnel are shifted from one geographical area to another.

Another question for improving targeting is, "Who is responsible?" Targeting at the Federal level requires large amounts of resource-specific information and additional staff to review, compare, and select among project proposals and then to monitor the progress of selected projects. Allowing States, which are presumably closer to the problems, to do the targeting raises issues of how to maintain accountability and control, particularly when Federal funds are involved.

Further Removal of Policy and Program Inconsistencies

Agricultural policy reforms in the 1985 and 1990 farm legislation could be expanded to further reduce inconsistencies between agricultural commodity programs and conservation and environmental quality programs. These inconsistencies relate mostly to high commodity program prices that influence the location and mix of crops and the intensity of agricultural chemical use. Removing or reducing price supports would alleviate the major inconsistency with conservation and environmental programs. But, at the same time, the current leverage of compliance, sodbuster, and swampbuster programs would be reduced.

Agricultural programs could more fully integrate conservation-environmental components with agricultural production components in the relevant policies and programs. Complementary changes could include targeting nonpoint source pollution problems identified in section 319 and Federal Coastal Zone Management Plans, broadening the environmentally sensitive land in land retirement programs, and increasing funding for conservation and environmental program components of agricultural program legislation.

Expanded or Continued Retirement of Critical Lands

Retirement of highly erodible and other environmentally sensitive cropland from production and its placement under permanent cover, as in the CRP, is an effective way to reduce erosion and to provide water quality and wildlife habitat benefits on individual farms as well as in conservation priority areas such as watersheds. However, it is often more expensive per ton of erosion reduced than implementing improved practices unless there is also a need to control supply of program crops. Expansion or continuation of the CRP will require new appropriations and a political decision that a joint supply control/conservation program is desirable. If appropriations are not forthcoming, and to some extent even if they are, many CRP lands will return to crop production after contracts begin expiring in late 1995.

Some options for continuing the CRP, ranging from the most costly to the least costly in terms of appropriations, are:

1. Continue to make the program available, accepting both new lands and renewing contracts on existing lands in the CRP for 5-10 years.

2. Target the program only to the most critical lands, both in accepting new lands and renewing contracts on existing lands.

3. Limit the program only to renewing contracts on the most critical lands already enrolled in the CRP. This could mean that where a whole field was originally in the program, only the most critical portion of the field (for example, a filter strip) might receive rental or easement payments to continue under permanent cover.

Increased Use of Conservation Compliance Provisions

Conservation policy has shifted program emphasis from short-term, single-field, production-oriented practices to implementation of long-term, whole-farm, conservation-oriented plans (Ervin, Heimlich, and Osborn, 1991). The effectiveness of conservation compliance measures in targeting erosion and nonpoint source pollution is so far untested on a broad scale and depends upon continuing long-term public and farmer support. Administering compliance provisions requires increased local technical capability, administrative resources, and strong local political support. As used in current farm programs, the compliance mechanisms primarily address erosion concerns. However, compliance measures could be devised to address other environmental problems, such as the leaching of farm chemicals to ground water.

Conservation compliance farm plans could be expanded from erosion control alone, to include comprehensive conservation-environmental planning for the abatement of whatever agricultural nonpoint source pollution threatens a particular area. However, the delivery of traditional assistance programs would have to be expanded to support the implementation of the practices and services required to deal with broader agricultural pollution problems and to ensure farmer compliance.

Regulation

Adoption of regulatory features would be a divergence from the traditional voluntary approach of U.S. conservation programs and would increase Government involvement in farm operations (Reichelderfer, 1990). Regulations could be used to target specific environmental objectives for areas with critical pollution problems or threats. Such regulations could include requiring the use of certain best management practices (BMP's), banning certain management practices, or restricting chemical and other input use.

Conservation Tax Incentives

Tax incentives can encourage farmers to invest in soil and water conservation practices. Certain soil and water conservation costs are currently tax deductible but are limited to 25 percent of the gross income from farming during the taxable year. Further tax deductions or the use of tax credits are possible ways of increasing incentives toward improved practices that reduce erosion or other pollutants.

Expanded Technology Research

Public policy during the past two decades has increasingly stressed farming methods that mitigate the off-farm effects of pollutants generated within agriculture. The evolution from individual conservation practices to BMP's and recently to integrated management systems reflects experience with and research on conservation techniques adaptable to modern farming.

Increased interest in and research on "sustainable agriculture" approaches are occurring that incorporate soil-conserving and chemical-input-reducing practices. Major "sustainable" practices and systems include crop rotations that moderate weed, disease, and insect problems, pest scouting to determine when pests reach critical levels, soil and water conservation, animal waste management, and biological pest controls. Possible topics for expanded research include (1) effects of wide adoption of "sustainable" systems, and (2) factors affecting farmers' adoption of sustainable systems.

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